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ENGINEERING:

An Illustrated Weekly Journal.

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APR 4 1922

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Diesel Engines, Six Cylinder, two and four stroke, 850, 1000, 1200 H.P. Excellent condition. Dynamos for above 250 or 500 Volts, D.C. Immediate delivery and low price. Also 3-400 Kw. PARSONS TURBINE SETS, 250 or 500 Volts D.C., with Condenser and spare armature. ELECTRICALLY DRIVEN AIR COMPRESSORS, 250 Volts D.C. Pressures 1000 to 3000 lbs. per square inch. JENNINGS, West Wall, Newcastle-on-Tyne. 9743

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Forgings. **Walter Somers, Limited,** HALMSOWEN. 7116

Head, Wrightson & Co., LIMITED. See Advertisement page 61. 2402

Taylor & Challen Presses 8106 About 200 NEW PRESSES in Stock in our Showrooms for immediate delivery at specially Reduced Prices. TAYLOR & CHALLEN, LTD., Engineers, Constitution Hill, BIRMINGHAM. See Full page Advertisement page 65, March 3.

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The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMMYER, M.I.C.E.
Founded 1854 by SIR WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 598

Institution of Municipal and COUNTY ENGINEERS.

TRIALS, DEMONSTRATIONS AND KINEMATOGRAPH EXHIBITION OF PLANT AND PROCESSES OF INTEREST TO MUNICIPAL AND COUNTY ENGINEERS.

ANNUAL MEETING AND CONFERENCE, CARDIFF,
JUNE 21, 22, 23, 24, 1922.

The Institution is undertaking a series of trials and demonstrations with the object of enabling members of the Institution and representatives of Local Authorities accompanying them to see the apparatus in operation under normal working conditions, to give manufacturers the opportunity of showing what their plant will perform under such conditions, and to gain useful knowledge of the duty required and of the comparative efficiency of various similar appliances now on the market.

The following are the proposed classes for the "Trials."

1. Self-propelled Road-Sweeping Apparatus.
2. Combined Road-Sweeping and Loading Apparatus.
3. Road-Tarring Apparatus.
4. Road-Gritting Apparatus.
5. Mechanical Loading Apparatus.
6. Concrete Mixers.
7. Electrical Vehicles.
8. Combination of any of the foregoing Apparatus.

Other plant and processes may be entered for the "Demonstrations" and Kinematograph Exhibition.

Regulations and Forms of Entry may be obtained from the SECRETARY, Institution of Municipal and County Engineers, 92, Victoria Street, London, S.W. 1. T 795

Correspondence Courses for

B.Sc., Inst. C.E., I. Mech. E., all ENGINEERING EXAMS. Special Courses and Single Subjects. Personal tuition.—For full particulars apply to Mr. TREVOR W. PHILLIPS, B.Sc. (Hons.), Assoc.M.Inst.C.E., M.I.E.S.I., etc., 8-10, Trafford Chambers, 58, South John Street, Liverpool. 575

Inst. C.E., I. Mech. E., B.Sc.,

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as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "O" embraces 25 years' professional experience. Address, 7434, Offices of ENGINEERING.

TENDERS.

Tenders are Invited by

the GOVERNMENT of NEW SOUTH WALES for the CONSTRUCTION of the SUPERSTRUCTURE and SUBSTRUCTURE of a CANTILEVER BRIDGE ACROSS SYDNEY HARBOUR from DAWES POINT to MILSON'S POINT, embracing a main span of 1600 ft. in the clear, centre to centre of main piers, or 2600 ft. centre to centre of anchor piers. The total length of bridge included in tender is 3618 ft., centre to centre of abutments. The deck of the bridge is to include four lines of railway, and a roadway 35 ft. wide, between main trusses; and cantilevered outside the main trusses on the western side, a footway 15 ft. wide, and on the eastern side a motor roadway 18 ft. wide. Copies of specification, including plans, general conditions, and schedule of quantities may be obtained on application to the undersigned.

To give any information required by Tenderers, Mr. J. J. C. BRADFIELD, Chief Engineer, will be in London during June and July, 1922, address care of the undersigned.

Tenders in accordance with the specification must reach the Under Secretary for Public Works, Sydney, not later than 31st October, 1922.

AGENT-GENERAL
FOR NEW SOUTH WALES.
Australia House, Strand, London, W.C. 2.
December, 1921. T 34

TYNE IMPROVEMENT COMMISSION.

SWING BRIDGE, NEWCASTLE-UPON-TYNE.

The Tyne Improvement Commissioners are prepared to receive

Tenders for the Repair of

the GIRDER WORK of the SWINGING PORTION of the NEWCASTLE SWING BRIDGE.

Copies of the Form of Tender, Conditions of Contract, Specifications and Drawings can be obtained from this Office on payment of a deposit of Two Guineas. The deposit will be returned on receipt of a *bona fide* Tender with all the prescribed documents and drawings.

Tenders in sealed envelopes, endorsed "Tender for Repairs, Newcastle Swing Bridge," to be addressed to the undersigned, and delivered to him not later than Noon on Saturday, the 15th of April, 1922.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
J. McD. MANSON,
General Manager & Secretary.
Tyne Improvement Commission,
Newcastle-upon-Tyne.
22nd March, 1922. T 785

THE BURMA RAILWAYS CO., LTD.

The Board of Directors of the Burma Railways Co., Ltd., are prepared to receive

Tenders for the Supply of :—

(a) 723½ tons STEEL MATERIAL (Mild Steel Channels, Angles, Flats and Rounds).
(b) 25 tons WROUGHT IRON FLATS.
(c) 60 tons CAST IRON PIPING.
(d) 14,450 Lin. feet Galvanized W.I. or Mild STEAM PIPING, AND 84 BENDS.
(e) 400½ dozen FILES.

For each copy of the Specification (a) a fee of 20/- will be charged, for each copy of Specification (b), (c) and (d) a fee of 10/- will be charged, and for each copy of Specification (e) a fee of 5/- will be charged, which fees are not returnable. Tenders, enclosed in sealed envelopes endorsed "Tender for Steel Material" or as the case may be, must be delivered at the Company's Offices not later than Twelve noon on Monday, 3rd April, 1922. The Directors do not bind themselves to accept any or the lowest Tender and reserve the right to divide the order.

By Order of the Board,
F. C. FRANKS,
Secretary.
109, Gresham House,
Old Broad Street,
London, E.C. 2.
22nd March, 1922. T 790

CITY OF CHICHESTER.

WATER DEPARTMENT.

PUMPING MACHINERY.

The Town Council of the City of Chichester invite

Tenders for the Supply and

ERECTION of suitable TRIPLE RAM PUMPS, at their Waterworks Pumping Station, for pumping 40,000 gallons per hour against a static head of 130 feet, but later on the duty will be increased.

Tenders are invited for Pumping Units driven by Suction Gas Engines and also, alternatively, by Heavy Oil Engines or Electric Motors.

General Conditions, Specification and Form of Tender may be obtained from the City Engineer, Mr. FRANK J. LOBLEY, A.M.I.C.E., at his Office during the usual office hours, upon payment of a deposit of Four Guineas, which will be returned on receipt of a *bona fide* Tender and the return of any documents supplied.

Tenders in sealed envelopes, endorsed "Waterworks Contract, No. 2," &c., are to be received not later than the first post on Wednesday, the 5th day of April, 1922.

The Council do not bind themselves to accept the lowest or any Tender.

J. W. LOADER COOPER,
Town Clerk.
East Street,
Chichester,
20th March, 1922. T 786

CITY OF LEICESTER.
WATER DEPARTMENT.

PUMPING MACHINERY.

The Water Committee of the City of Leicester invite

Tenders for the Supply and

ERECTION of OIL or GAS ENGINES and PUMPS for pumping continuously 50,000 gallons of water per hour through about 70,000 feet of 14 inch diameter pipes against a static head of 122 feet.

General Conditions, Specification and Form of Tender may be obtained from G. T. EDWARDS, Esq., M.Inst.C.E., Water Engineer and Manager, Bowling Green Street, Leicester, on deposit of a cheque value five pounds which will be returned on receipt of a *bona fide* Tender, and the return of all documents supplied.

Tenders endorsed "Pumping Machinery" are to be delivered to the undersigned in a sealed envelope on or before Ten a.m. on April 10th next.

The Committee do not bind themselves to accept the lowest or any Tender.

G. T. EDWARDS, M.Inst.C.E.,
Engineer and Manager.
Waterworks Office,
Bowling Green Street,
Leicester. T 729

COUNTY BOROUGH OF BIRKENHEAD
WATER COMMITTEE.

FOR SALE.

The Corporation are prepared to receive

Offers for the following

PUMPING PLANT, which is FOR DISPOSAL, owing to the coming into operation of a new Gravitation Supply, and is all in excellent working condition.

A Compound Rotative Beam Engine, surface condensing with bucket and plunger pumps, capacity 80,000 gallons per hour with a total lift of 303 feet at a boiler pressure of 90 lb. per square inch HP., Cylinder 30 in. dia. by 3 ft. 10 in. stroke, L.P. Cylinder 50 in. dia. by 7 ft. stroke, Bucket 7 ft. stroke.

Two Triple Expansion Horizontal Duplex Pumps, steam cylinders 10 in. to 16 in. and 25 in. dia., water cylinder 14 in. dia. by 18 in. stroke, capacity (each) 45,000 gallons per hour against a head of 200 feet at a boiler pressure of 150 lb. per square inch.

Two Surface Condensers, Wheeler Admiralty Pattern, 2 ft. 4 in. dia. by 6 ft. 10 in. between tube plates, 433 ¾ in. copper tubes (each), with steam driven horizontal Air Pumps complete.

Two Lancashire Boilers, 30 ft. by 7 ft. by Tetlow Bros., insured for 160 lb. W.P.

One Lancashire Boiler by The Oldham Boiler Works Co., Ltd., insured for 100 lb. W.P.

Two Lancashire Boilers by The Oldham Boiler Works Co., Ltd., insured for 100 lb. W.P.

All the Boilers above mentioned are fitted complete with Hopkinson Valves and mountings.

Any further information and also permits to view the Plant may be obtained from the BOROUGH WATER ENGINEER, 53, Balls Road, Birkenhead, to whom Offers for the whole or portions of the Plant should be sent not later than April 14th, 1922.

Water Engineer's Office,
16th March, 1922. T 791

CORPORATION OF LOUGHBOROUGH.
ELECTRICITY DEPARTMENT.

The Corporation of Loughborough invite

Tenders for Extra High

PRESSURE SWITCHGEAR AND EXTENSIONS TO DIRECT CURRENT SWITCHGEAR.

Copies of Specification with Form of Tender, General Conditions and Drawings, can be obtained of the undersigned either at 7, Victoria Street, Westminster, S.W. 1, or 11, Mosley Street, Manchester. A deposit of Three Guineas in respect of each Specification is required, which will be returned as soon as the Contract is let, provided that a *bona-fide* Tender be submitted and not withdrawn. Duplicate Specifications will be supplied on payment of half-a-guinea each, which sum is not returnable.

Tenders, enclosed in envelope sealed with wax, clearly endorsed "Tender for Switchgear, Loughborough," must be addressed to the THE TOWN CLERK, Town Hall, Loughborough, and must be delivered not later than Noon on April 14th, 1922.

C. H. WORDINGHAM,
M.Inst.C.E., M.Inst.E.E.,
Consulting Engineer. T 776

APPOINTMENTS OPEN.

CHESHIRE COUNTY COUNCIL.
EDUCATION DEPARTMENT.

NORTHWICH VERDIN TECHNICAL SCHOOL AND SCHOOL OF ART.

Wanted, for September next,

a FULL-TIME ADDITIONAL LECTURER for Major Engineering Course. An Engineering Graduate with Works and Teaching Experience preferred. Salary in accordance with the Burnham Scale.

Forms of Application and further particulars may be obtained from A. E. THOMAS, Esq., Education Office, Northwich.

C. F. MOTT, M.A.,
Director of Education. T 721

STAFFORDSHIRE EDUCATION COMMITTEE.
COUNTY TECHNICAL COLLEGE,
WEDNESBURY.

An Assistant Lecturer in

Engineering is REQUIRED. Salary will be paid according to the Burnham (Technical School) Scale.

Candidates must be qualified to give class-room and laboratory instruction in Mechanical Engineering and related subjects. Works experience is desirable.

Further particulars and forms of application, which must be returned not later than 20th April, may be obtained from the undersigned on receipt of a stamped addressed envelope.

GRAHAM BALFOUR,
County Education Offices, Director of Education.
Stafford, March, 1922. T 783

Chemist and Metallurgist

REQUIRED, to take charge of Chemical, Metallurgical and Mechanical Testing Laboratories. Salary £460 per annum, plus Civil Service Bonus (at present £345). Applicants must possess recognised academical qualifications and have had experience of modern practice in the manufacture of iron and steel and non-ferrous metal alloys, and in the heat treatment of large and small masses of carbon and alloy steels; they must also have some knowledge of modern methods of mechanical testing. — Applications, giving particulars of qualifications and experience, should be addressed, CHIEF SUPERINTENDENT of Ordnance Factories, Royal Arsenal, Woolwich. T 775

An Engineering Firm Re-

QUIRE the SERVICES of a well-educated trained ENGINEER, who has specialised in steam generation, to act as foreign selling representative. Knowledge of French and German essential; additional languages not absolutely necessary, but strong recommendation. Age between 25 and 30.—Address, giving full particulars of education, engineering training and experience, also state salary expected, T 779, Offices of ENGINEERING.

MERSEY DOCKS AND HARBOUR BOARD.

GLADSTONE DOCK NEW WORKS.

The Board require the

Services of a Fully-Qualified

RESIDENT ENGINEER under 40 years of age, who must be either a Member or an Associate Member of the Institute of Civil Engineers, to take charge of the above Works, under the direction of the Engineer-in-Chief to the Board.

Candidates must have been in charge of Heavy Dock Construction Work,—and had experience in Reinforced Concrete Works,—Steel Temporary Dams,—Electrical Machinery of all descriptions,—Steel Dock Gates, and Hydraulic Machinery.

Applications, with testimonials and stating salary required, to be addressed to the undersigned, and delivered not later than April 10th, and marked on the envelope "Application for Resident Engineer."

L. A. P. WARNER,
General Manager and Secretary.
Dock Office, Liverpool, March 20, 1922. T 793

BRITISH NORTH BORNEO.

Required Immediately in the

PUBLIC WORKS DEPARTMENT OF NORTH BORNEO, TWO ENGINEERS.

Candidates should be single and under 30 years of age; active, of good physique, with thorough knowledge of instrument work and well trained in ordinary engineering knowledge; must have been trained in a recognised Engineering College and should have passed A.M.I.C.E. Exam., or hold exempting degree; should have had good practical experience on Public Works. Preference for one appointment will be given to candidate with Waterworks experience.

Salary £490, rising annually by £21 with house or house allowance, and duty allowance of £56. Five years' agreement, with first-class free passage out and home on completion of agreement. Appointment subject to medical examination.

Apply (in writing) not later than 3rd April, with full record of career in chronological order, giving age and details of general and technical education, training and subsequent experience, testimonials (Copies only), service certificates, etc., to Messrs. RENDEL, PALMER & TRITTON, 12-14, Dartmouth Street, S.W. 1. T 731

Works Manager Required for

a Railway in Southern Brazil, salary 2:000,000 (2 contos of reis) a month, age 30-35. Qualifications must include apprenticeship, drawing office experience (at least two years), certified technical training. Experience in charge of workshops or equal. Knowledge of Portuguese, Spanish or French desirable.—Applicants should give full particulars of education, training and experience, by letter, to FOX & MAYO, Consulting Engineers, 155, Dashwood House, New Broad Street, London, E.C. 2. T 804

A Progressive Press Tool Co.

REQUIRES the SERVICES of a fully skilled UNDER-MANAGER. Excellent prospects for right man. Willing to bring in £250-£500 capital.—Address, T 782, Offices of ENGINEERING.

Wanted, Salesman with

connection capable of handling Steam Specialities, Feed Pumps, etc. Salary and previous experience.—Address, T 680, Offices of ENGINEERING.

London Representative

WANTED by a firm of Constructional Engineers in the North to secure orders for Pit Tube, Light Railway Stock and Constructional Steelwork. To a suitable man the prospects are good and a high salary and bonus will be paid. Reply should state in confidence age, experience, references and suggested remuneration.—BOX 1228, WILLINGS, 30, King Street, Covent Garden, W.C. 2. T 800

For Modern Die-Casting

Works in London, WANTED a MAN of ability and standing with good personality. Will have good scope. Must be capable of controlling the commercial side of the business as well as the technical.—Address, with full particulars past experience, age, references and salary required, T 818, Offices of ENGINEERING.

Wanted, Draughtsman ex-

perienced in heating, ventilating and constructional engineering.—Apply, stating age, salary, experience, to LEWIS & GRUNDY, LTD., Heating and Constructional Engineers, Nottingham. T 784

Articled Pupil.—Civil Engi-

NEER, M.Inst.C.E., Cambridge Graduate, HAS VACANCY in his Office, Waterworks, Sewerage, Bridges, Buildings, Roads, etc.—For further particulars address, T 654, Offices of ENGINEERING.

SITUATIONS WANTED.

Buying Engineer. — The

Manager of a large Engineering Works Purchasing Department, who has an exceptionally wide knowledge of the Markets of the Country, DESIRES to Negotiate NEW APPOINTMENT.—Write, Z. M. 618, care of DEACON'S, Leadenhall Street, E.C. 3. T 806

Engineer (28), Technical

education, practical training. Experience as Chief Draughtsman and Works Manager, DESIRES POST as Technical Assistant or training in special brand of Engineering for Commercial purposes.—Address, T 644, Offices of ENGINEERING.

Eustace Archer, Civil Engineer

of 20 years' standing (10 years in London), at present employed on important railway construction in Norway, SEEKS POSITION in Australia or New Zealand as leading engineer for location and construction of section or whole railway line. Excellent testimonials and college degree.—Reply, BOX V. 99, NATIONAL ADVERTISING SERVICE, St. Ann's Chambers, Ludgate Hill, E.C. 4. T 361

Civil Engineer, M.Inst.C.E.,

DESIRES CHANGE of Employment, United Kingdom, Colonies or abroad. At present abroad, but could be free at the end of this year. 20 years' experience in irrigation, river protection works, land drainage and hydro-electric development, largely heavy construction.—Address, T 778, Offices of ENGINEERING.

Young Civil Engineer and

Boilermaker, general all-round handy man, SEEKS POSITION anywhere in U.K.—Address, T 802, Offices of ENGINEERING

Mechanical Engineer (28),

12 years' Works and Drawing experience. Expert Jig and Tool Designer. Moderate Salary for progressive post.—T 771, Offices of ENGINEERING.

Marine Engineer, age 29,

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LOW TEMPERATURE ROTARY

SENSIBLE HEAT DISTILLATION, LIMITED

(For Description see Page

Fig. 5.

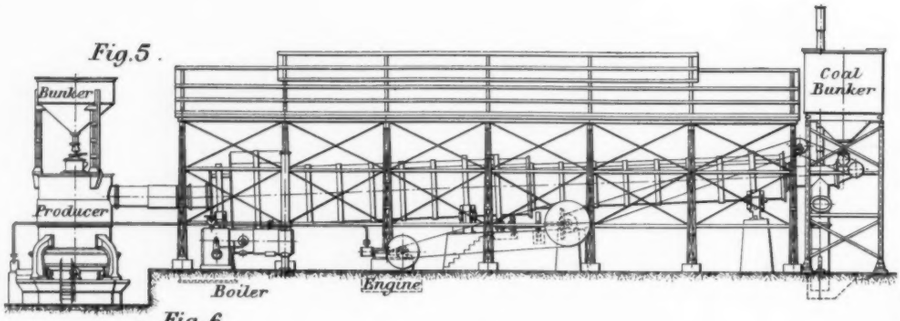


Fig. 8.

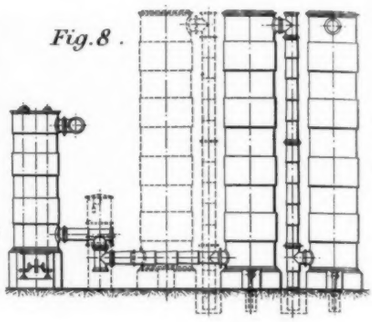


Fig. 6.

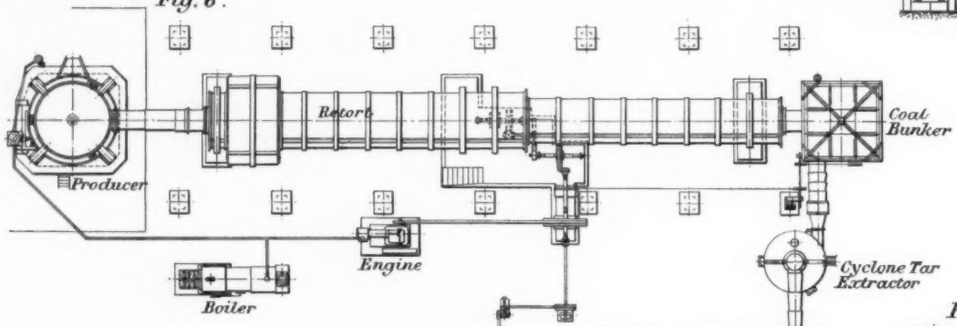


Fig. 7.

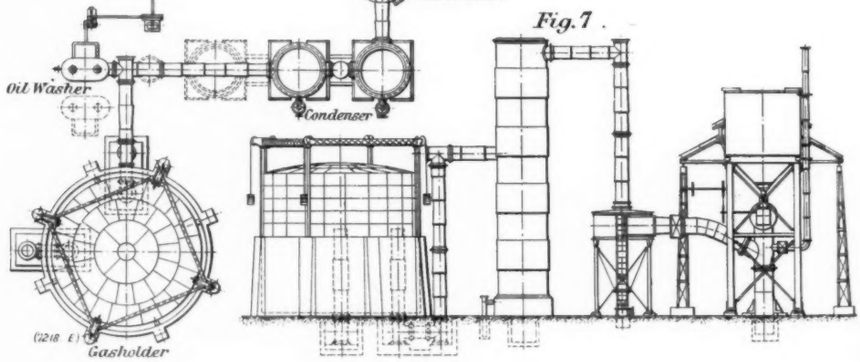
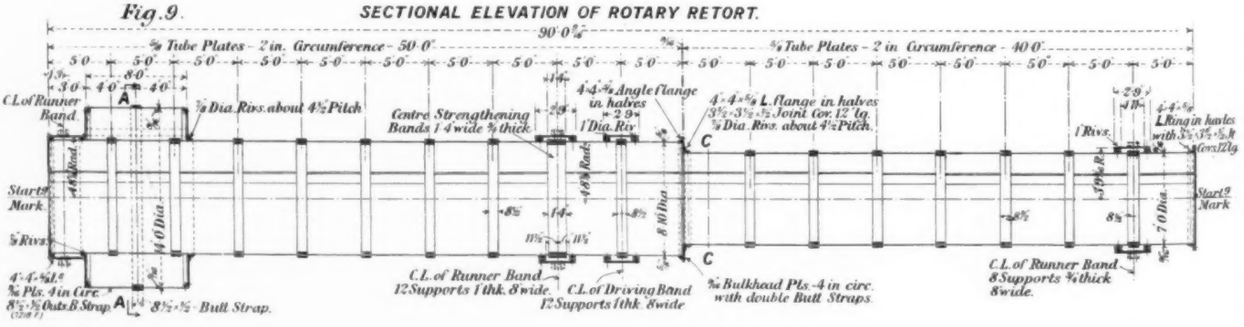


Fig. 9. SECTIONAL ELEVATION OF ROTARY RETORT.


90'0"
⅝ Tube Plates - 2 in. Circumference - 50'0"
⅝ Tube Plates - 2 in. Circumference - 40'0"
C.L. of Runner Band
⅞ Dia. Rivs. about 4½ Pitch
Centre Strengthening Bands 1 4 wide ⅝ thick
4-4-⅝ Angle Flange in halves
1 Dia. Riv
4-4-⅝ L. flange in halves
⅞ Dia. Rivs. about 4½ Pitch.
L Ring in halves
Start & Mark
⅞ Rivs
14'0 Dia
8'10 Dia
7'0 Dia
4-4-⅝ L's ⅝ Pls. 4 in Circ.
8½-⅜ Outs. B Strap
8½-½ Butt Strap.
C.L. of Runner Band 12 Supports 1 thk. 8 wide.
C.L. of Driving Band 12 Supports 1 thk. 8 wide
⅝ Bulkhead Plts. 4 in circ. with double Butt Straps.
C.L. of Runner Band 8 Supports ¾ thick 8 wide.

SEC. ELEVATION A-A
Fig. 10. 14'0 DIA. DRUM.

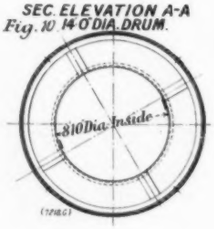


Fig. 11.
SECTION ON C-C SHOWING BULKHEAD.

DETAIL SHOWING JOINTING BULKHEAD PLATE

Fig. 12.

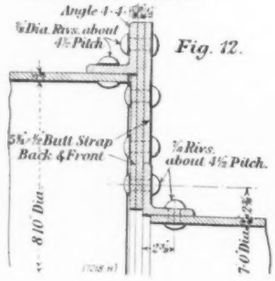
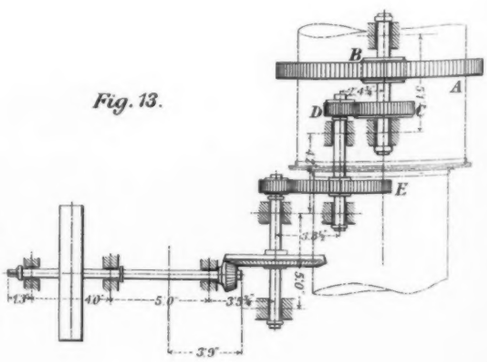


Fig. 13.

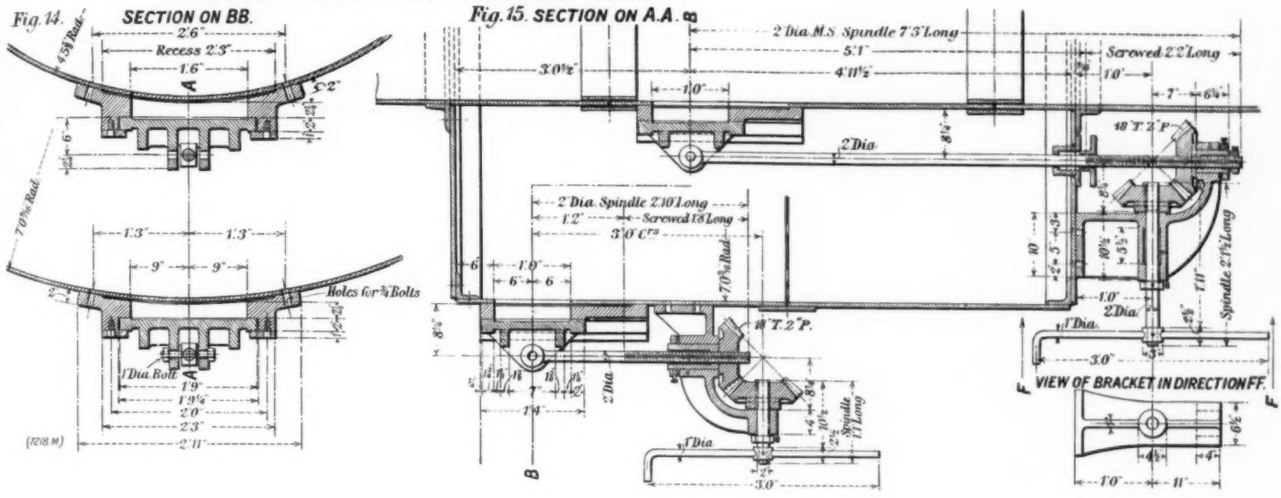


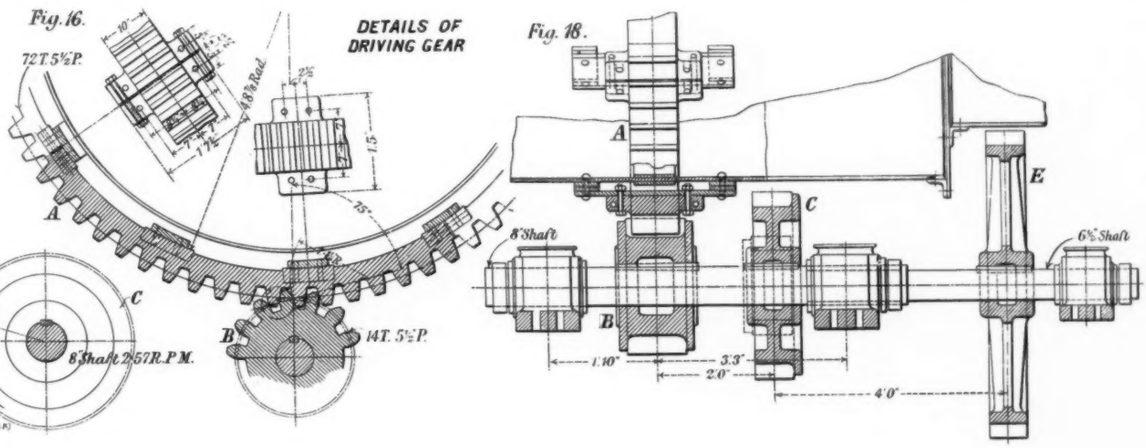
OTARY CARBONISING PLANT.

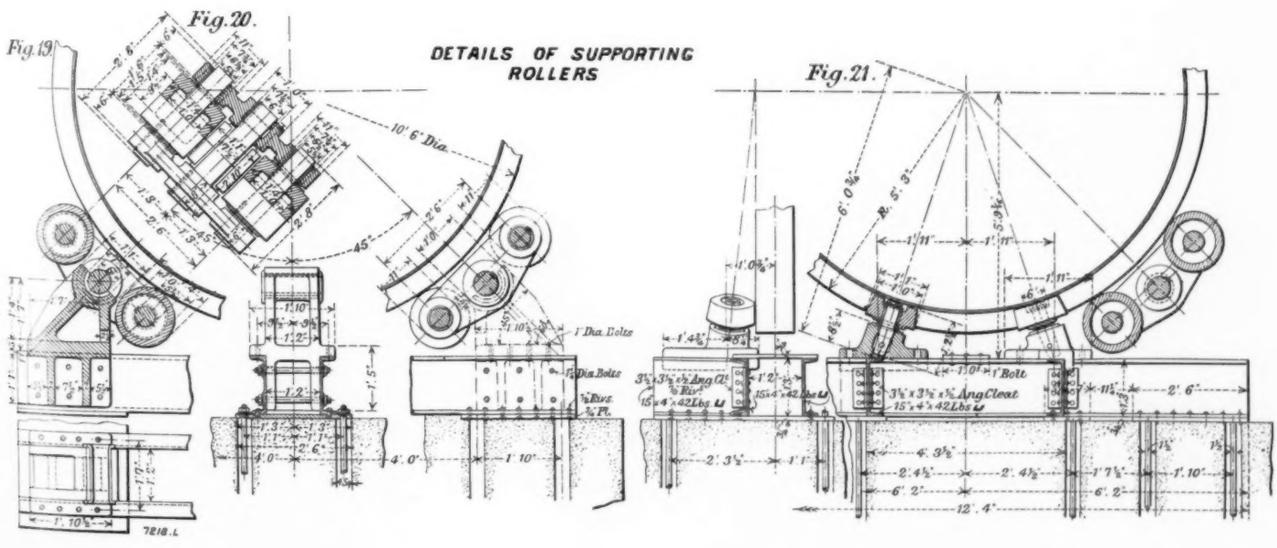
ATION, LIMITED, ENGINEERS, LONDON.

cription, see Page 347.)

DISCHARGE DOORS AND OPERATING GEAR







PRODUCER GAS FOR FURNACE WORK.

THE ordinary gas producer plant makes gas having a calorific value of about 150 B.Th.U. per cubic foot, which leaves the producer at a temperature of about 780 deg. C. If this gas is cooled down to a normal temperature before use, by passing through any apparatus in which its heat is not usefully recovered, there is a very material loss of efficiency, for the sensible heat thus thrown away will amount to something like 14–18 per cent. of the calorific value of the fuel from which the gas was made. Moreover, if the cooler gas is to be used for furnace work, it will be considerably less effective because its flame temperature will obviously be lower than if the gas had been red-hot at the time of ignition. Indeed, for many purposes the flame temperature of cool gas will be too low for proper working. Hence, both for reasons of thermal efficiency and also to get the highest flame temperature, a gas producer plant for furnace heating is always placed as close as possible to the furnace, the hot gas passing directly into the combustion chamber of the furnace. This arrangement, however, has many drawbacks. The producers occupy valuable space in the forge or other working area, and the work is liable to be interfered with by the transportation of fuel and ashes to and from the producers. The hot gas, moreover, is not easily controllable and the absence of any kind of storage makes it necessary for the producer to be worked at all times exactly in accordance with the requirements of the furnace, if satisfactory results are to be obtained.

Fig. 1. PERCENTAGE OF VOLATILE MATTER LEFT IN L.T. COKE (EXTERNALLY HEATED RETORT).

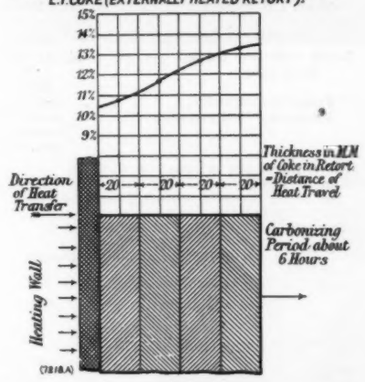
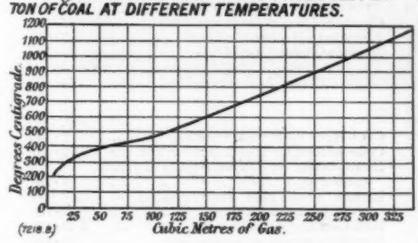


Fig. 2. CUBIC METRES OF GAS PRODUCED PER TON OF COAL AT DIFFERENT TEMPERATURES.



In order to improve the overall efficiency of the manufacture of producer gas, and at the same time to permit of the recovery of the valuable by-products which are destroyed in ordinary producer plants, Mr. Harald Nielsen has devised a type of plant which is of very great interest, theoretically as well as commercially. It consists essentially of the combination of an ordinary producer with a low-temperature carbonising retort, in which partial distillation of the raw coal is effected by the sensible heat of the producer gas. The hot gas from the producer passes down through the retort, in which it comes into actual and intimate contact with the raw coal. It distils off and carries with it the lighter hydrocarbons, and emerges cool and of a much greater calorific value than when it entered. The valuable ammonia, tar and oil can be extracted by the ordinary methods, and the gas, even then, is much more effective for heating or power purposes, than if it had been used directly from the producer. The partially-coked coal in the retort, moreover, makes excellent fuel for the producer, so that by suitably proportioning the plant, an extremely efficient combination is secured, taking in raw coal and turning out a cool and comparatively rich gas, from which the saleable constituents may be separated before use. The gas, being cold, can be stored in a holder and piped to any point desired, the producer plant and retort being erected on any place where its location is most convenient.

The process is known as the L.M.N. process, and is owned and controlled by Messrs. Bryan Laing, F. D. Marshall and Harald Nielsen, of 100, Victoria-street, S.W. 1. The L.M.N. process is not only important when gas-making is the primary object, but it constitutes a notable contribution to the problem of carbonising coal at a low temperature. Work in this direction has been proceeding actively of late, primarily with the object of producing a smokeless and clean domestic fuel, with the recovery at the same time of the smoke-forming constituents of the coal in the form of valuable oils. When coal is carbonised by the ordinary gas works process, the retorts are worked at the highest practicable temperature, as this ensures the greatest yield of gas per ton of coal. The coke so formed is hard and contains so little volatile matter that it does not make a good fuel for general domestic purposes and the high temperature of the retort destroys much of the ammonia which might otherwise be recovered. The same cause limits the quantity of tar oils which are produced, and the latter are mainly of the benzene series. When, on the other hand, coal is carbonised at the comparatively low temperature of 550 deg. to 600 deg. C., although the gas yield is very much less, the coke is softer and more suitable as a domestic fuel as well as for by-product producers fuel, while the yield of tar oils is very much greater. These latter, moreover, are of the paraffin series, and more suitable for fractionating into petrol fuel oils, lubricating oils, &c.

Fig. 3.

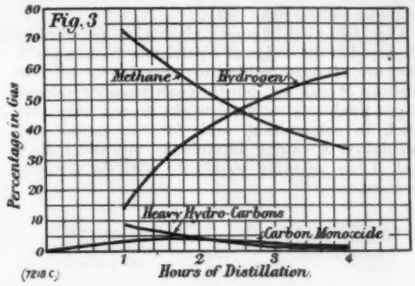
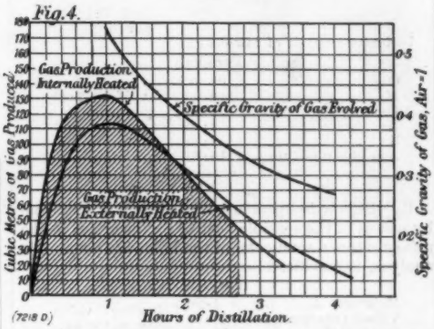


Fig. 4.



The great practical difficulty in low-temperature carbonisation consists, as is generally known in heating the coal uniformly within a reasonable period of time. Coal is so bad a conductor of heat that, with the small temperature gradient available, it becomes necessary to heat it in thin layers. This involves narrow, flat retorts, from which it has been found exceedingly difficult to dislodge the carbonised charge, as the coal swells a good deal during the carbonising process and jams itself in the narrow channel as an almost immovable mass. This difficulty has seemingly been got over by the use of collapsible plates inside the retorts as described in our article last year dealing with the Barugh Low-Temperature Carbonisation Works. Nevertheless, the practical drawbacks remain that the coal has to be dealt with in layers from 3 in. to 4 in. only in thickness, and even then the process of carbonisation cannot be effected in much less than 6 to 8 hours. Even under such conditions the degree of carbonisation is not uniform throughout the thickness of the slab of coke. Fig. 1, annexed, shows the result of some experiments carried out by Mr. Nielsen to determine the variation. A slab of coke about 3 in. thick carbonised by the usual low-temperature process for about 6 hours, was cut into four layers parallel to the retort wall. The percentage of volatile matter contained in each layer was determined separately, and the diagram shows that the figure varied from about 10·5 per cent. on one side of the layer to 13·5 per cent. on the other.

The succeeding diagrams, Figs. 2, 3 and 4, illustrate graphically some of the more important facts which characterise the distillation of coal under different conditions. Fig. 2 shows approximately the volume of gas yielded per ton of coal carbonised at different temperatures. In Fig. 3 curves are given to show the way in which the composition of the gas changes as carbonisation proceeds under low-temperature conditions. It will be noted that the yield of the most valuable constituents, namely, methane, carbon monoxide, and the heavy hydrocarbons, reaches its maximum value during the first 2 hours of treatment, and then gradually decreases while the hydrogen constituent increases as time goes on. After about 2½ hours' distillation, the methane curve cuts the hydrogen curve, and there is reason for believing that the period of distillation should not be extended much beyond this point, provided that the coal can be carbonised throughout in that time. This, however, is not possible with externally heated retorts unless the layer of coal is limited to 1½ in. or 2 in. in thickness, which is not commercially practicable.

The benefit of rapid carbonisation is also shown by the curves in Fig. 4. The specific gravity curve is of special interest. The increasing hydrogen percentage, illustrated in Fig. 3, is reflected in the reduction of the specific gravity of the gas as time proceeds. The falling-off in specific gravity between the first and the third hour of carbonisation is very marked, and the heating value of the gas per unit of volume falls away according to almost the same curve. The same diagram, Fig. 4, also shows the relative rate of gas production by internally-heated and externally heated retorts, respectively. With retorts of the former type the yield rises more quickly to a maximum and falls much more abruptly. The areas under the curves for internally-heated and externally-heated retorts, represent the total respective volumes of gas given off during the time indicated, and by measuring these areas it will be found that while 75 per cent. to 80 per cent. of the total yield of low-temperature gas is given off during the first 2½ hours with internally-heated retorts, the corresponding figure for externally-heated retorts is only from 70 per cent. to 75 per cent. in the same period. All these facts point to the advisability of rapid carbonisation and it is, moreover, obvious that by reducing the carbonising period to one-half or one-third the time ordinarily required, not only are the radiation losses per ton of coal carbonised greatly reduced, but the throughput of the plant is doubled or trebled. Such quick carbonisation, at low temperatures, can only be effected by bringing the exterior surface of every individual piece of coal into direct contact with the heating medium. By so doing, lumps of coal up to 3 in. cube can be carbonised throughout in less than 3 hours, the volatile constituents of the coke not varying more than 1 per cent. throughout any piece. If the coal is crushed to a smaller size before entering the retort, the time of carbonisation is, of course, correspondingly reduced.

The underlying principles of the Nielsen process having been now explained, we may proceed to describe the nature of the plant used for carrying them out in practice, taking as an example an installation in course of erection at the works of the Carbon Products Company, in India. The general arrangement of this plant, which is designed

to gasify 100 tons of coal per day, is shown diagrammatically in Figs. 5 to 8, on Plate XVII. Its most striking feature is a rotary retort 90 ft. long, varying from 7 ft. to 9 ft. in internal diameter. This is mounted with the larger end slightly lower than the other. Raw coal is fed into the smaller end from the bunker shown in Figs. 5 and 6, and the hot gas from a producer situated at the other end of the retort, traverses the interior of the latter for its full length. On its way it carbonises the charge, distilling off the more volatile hydrocarbons, and leaves the retort cooled and much enriched with the products of distillation. The gas then passes through the cyclone tar extractor shown in Fig. 6, to the condensers, where the oil is separated out, and thence to the gasholder. Fig. 9 gives particulars of the retort itself, while details of its construction, including the methods by which it is supported and driven are shown in Figs. 10 to 21, on the same Plate.

It will be seen that near its larger end, the retort is surrounded by an annular belt, 14 ft. in diameter, This is for the purpose of discharging the carbonised coal, which passes out through the hand-operated sliding doors illustrated in Figs. 14 and 15. The retort is caused to rotate by gearing, the arrangement of which is shown in Fig. 13. The final drive takes place through a spur-ring surrounding the retort near the centre of the latter, details of this drive being shown in Figs. 16 to 18. The weight of the retort is carried by supporting rollers, as shown in Figs. 19 to 21. Near each end of the retort and also at the centre of its length, is a runner band which runs on the rollers just mentioned. Endwise motion is prevented by thrust rollers working against the side of the runner band in the manner illustrated in Fig. 21. Fig. 22, on page 349, shows the retort during assembly in the works of Messrs. Ashmore, Benson, Pease and Co., Limited. by whom the plant was constructed, in conjunction with Messrs. W. C. Holmes and Co.

At the end of the retort at which the coal enters, is a fixed cylindrical portion, 3 ft. 6 in. diameter, carrying both the coal-feeding mechanism and the gas outlet branch. This portion enters the retort proper through a specially designed gland where gas tightness is assured by means of cast iron rings working on metallic surfaces only. The successful solving of the problem of keeping a very large diameter stuffing box tight under high temperatures is intimately connected with the successful working of a rotary retort.

The coal-feeding mechanism, and the method by which it is carried on the fixed portion is shown in Figs. 24 to 30, on page 350. A mechanical measuring device, driven by gearing, receives the coal from the overhead hopper and discharges it at the required rate into a trough, in the centre of which is a screw conveyor driven by the same gearing which actuates the measuring device. The conveyor which is nearly 10 ft. long, slowly traverses the coal to its inner end by means of the usual inclined paddles, as shown in Fig. 30. The coal then falls into the rotating portion of the retort and passes gradually to the other end under the influence of gravity assisted by the rotation. The hot gas enters the retort near the point where the carbonised coal is discharged, so that the contra-flow principle is utilised and the most efficient heat transfer from the gas to the coal is obtained. The gland through which the hot gas enters is in the centre of the lower end of the retort, is similar to that mentioned above. The gas producer illustrated in Figs. 31 to 33, on page 350, is specially designed for working in conjunction with rotary retorts. It has an internal diameter of 10 ft. and needs no detailed description as it is built in accordance with modern producer practice. The rotating ash-pan will be noticed, and other details will be clear from the illustrations.

In Fig. 34, on page 351, a diagrammatic drawing is given of a complete Nielsen low-temperature rotary retorting plant arranged for the complete gasification of the carbonised coal in automatically-fed producers, for the purpose of producing a cold, clean producer gas suitable for heating steel furnaces. As Mr. Archer Coulson pointed out recently in his presidential address to the Cleveland Institution of Engineers, owing to the comparatively small difference between the temperature of the flame and that of the bath during the greater part of the time a steel furnace is working, it was possible that a 10 per cent. increase in the calorific value of the gas would give an increase of more than 20 per cent. in the efficiency of the flame. The plant in question not only enables a certain proportion of the volatile constituents of the coal to be recovered in the form of valuable tar oils, but by mixing the gas from the producers with that generated in the rotary retort, the calorific value of the resultant mixture, after scrubbing, is brought up to about 180 B.Th.U. per cubic foot at standard pressure and temperature. The sensible heat of the producer gas made from the semi-coke is sufficient not only to carbonise the coal in the rotary retort, but also to raise sufficient steam to operate all the producers. The plant may be situated in any convenient position and the cold, clean gas carried to any desired point without heat loss, and therefore far more efficiently or conveniently than the hot gas leaving an ordinary producer can be dealt with.

The following figures give the calculations employed in the design of a particular Nielsen plant. They are, of course, subject to correction for different qualities of coal, &c., but the coals usually employed in gas producers for steel works do not vary very much in composition, and for the purposes of calculation a caking bituminous unwashed slack coal of the following proximate analysis has been assumed.

	Per Cent.	
Moisture	2·80	Heating value round 6,330 kg. cal. per kg.
Volatile matter ...	31·10	
Fixed carbon ...	53·70	
Ash	12·40	
	100·00 = 11,400 B.Th.U. per lb.	

Ultimate analysis of raw coal:

	Per Cent.	
C	68·00	
H_2	4·00	Net H_2 = 2·80 per cent.
O_2	9·70	
N_2	1·30	
S	1·80	
Ash plus moisture	15·20	
	100·00	

By the low-temperature distillation of this coal by means of the sensible heat of producer gas in the rotary retort a semi-coke of the following proximate analysis is produced:—

	Per Cent.	
Moisture	1·90	Heating value about 6,400 kg. cal. per kg.
Volatile matters ...	11·50	
Fixed carbon ...	70·70	
Ash	15·90	
	100·00 = 11,500 B.Th.U. per lb.	

The coke is cooled down below the igniting-point in the free atmosphere by being kept in contact with an inert gas (producer gas) in a cooling chamber fixed to the retort.

NOTE.—The moisture percentage in analysis was due to the exposure to the weather.

Ultimate analysis of semi-coke:

	Per Cent.	
C	71·20	
H_2	2·90	Net hydrogen = 2·30 per cent.
O_2	4·90	
N_2	1·50	
S	1·70	
Ash plus moisture ...	17·80	
	100·00	

Gasifying the semi-coke in a producer of the above-described type, a producer gas of the following composition is obtained:—

	Per Cent.
CO_2	6·00
O_2	0·40
CO	25·50
H_2	13·50
CH_4	2·60
N_2	52·00
	100·00

Total combustibles in gas: 42·6 per cent.
Net heating value of gas per m^3 N.P.T. 1,333·9 kg. cal. per m^3 = 152·5 B.Th.U. per cubic foot.
Total carbon per m^3 = 0·18388 kg.
Amount of gas produced per 1 kg. coke after deducting carbon losses in ash: 3·81 m^3, corresponding to 60 cub. ft. per pound semi-coke.
Oxygen requirements per m^3 gas = 0·27356 kg.

	Kg. O_2.
Total oxygen requirement per kg. coke, allowing for requirements of ash	1·0823
Deducting oxygen corresponding to nitrogen contents of gas per kg. coke	0·7528
	0·3295

This amount of oxygen has to be supplied in the form of steam.
Corresponding to 0·3707 kg. steam per kg. coke, or 0·3707 tons per ton of coke.
Heat of formation per m^3 producer gas:

COH = — 2·34 kg. cal.
CO_2 = 236·23 ,,
CH_4 = 25·87 ,,

Total amount of combined moisture formed per m^3 producer gas = 0·01445 kg. = steam formed.

	Kg. Cal.
Heat of formation corresponding to this amount	45·80
Deducting latent heat, plus superheat up to the reaction temperature (max. 1,100 deg. C.)	13·18
Net heat set free, kg. cal. ...	32·62

Total moisture carried per m^3 producer gas from coke—

	Kg.
From free moisture...	0·005
From combined moisture	0·01445
	0·01945

Air required per m^3 gas = 0·6582 m^3.
Amount of heat required to bring 0·6582 m^3 air up to reaction temperature (max. 1,100 deg.): 220·17 kg. cal.
Amount of steam required per m^3 gas:

$$\frac{0\cdot3707}{3\cdot81\ m^3} = 0\cdot09725 \text{ kg. at 60 lb. pressure} = 4 \text{ atm.}$$

PROCESS.

In.

Heat balance per m^3 producer gas:

	Kg. Cal.
CO_2 } Exothermic reactions ... CH_4 }	236·23 + 25·87
Coke, sensible heat carried per m^3 gas	1·10
Free moisture, sensible heat... ...	0·075
Combined moisture formation ...	45·80
Reaction air, sensible heat	3·06
Reaction steam, total heat	63·30
Total heat available ...	375·435

Out.

	Kg. Cal.
CO + H, endothermic reaction ...	2·34
Coke heated to reaction temperature	79·40
Evaporating and superheating of free moisture	4·79
Latent heat plus superheating of combined moisture	13·18
Reaction air, superheating	220·17
Reaction steam, superheating ...	52·15
Sensible heat in ash	3·40
Total heat consumed ...	375·43

Factors governing the outlet temperature of the producer gas:—

A. Radiation losses, &c., from producer:

	Kg. Cal.
According to Rambush's paper (Journal of the Society of Chemical Industry, June 30, 1921), these losses can be placed at about 1 per cent. Mr. Harald Nielsen has obtained figures from carbonising tests amounting to 1·2 per cent. of the total heating value of fuel gasified. The loss represents per m^3 gas produced under the above conditions	21·3
B. Sensible heat loss in ash	3·4
C. Superheating of excess steam introduced in the producer about 25 per cent., represents per m^3 gas produced, represents	10·25
Corresponding to 0·0324 kg. per m^3 gas.	
D. Amount of coke corresponding to 1 m^3 gas heated up to reaction temperature represents	79·40
E. Free moisture evaporated and superheated represents	4·79
Combined moisture represents ...	13·18
A+B+C+D+E = kg. cal. ...	132·32

Temperature of gas leaving producer:

$$\frac{375\cdot435 \text{ kg. cal.} - 132\cdot32 \text{ kg. cal.}}{0\cdot31 \text{ (specific heat per } m^3 \text{ gas)}} = 785 \text{ deg. C.}$$

Corresponding to 1,440 deg. F.
Total moisture carried per m^3 producer gas:
0·005 + 0·01445 + 0·0324 = 0·05158 kg.

LOW TEMPERATURE ROTARY CARBONISATION PLANT.

SENSIBLE HEAT DISTILLATION, LIMITED, ENGINEERS, LONDON.

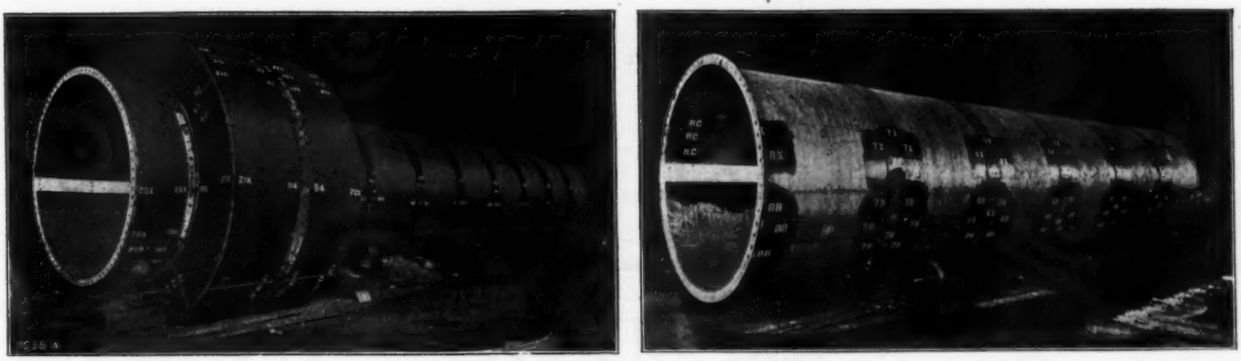


FIG. 22.

FIG. 23.

Total sensible heat of gas represents:

$$\frac{(375{\cdot}435 - 132{\cdot}32) \times 100}{0{\cdot}2625 \text{ kg. coke} \times 6{,}400 \text{ kg. cal.}} = 14{\cdot}4 \text{ per cent. on fuel value of coke.}$$

Thermal balance of producer per m³ gas. (Gas at 0 deg. C. and 760 mm. Hg.)

In.

	Kg. Cal.
Coke, 0·2625 kg. at 6,400 =	1,680·000
Sensible heat of coke	1·100
Sensible heat of air blast	3·060
Total heat of reaction steam	63·200
Total heat of excess steam	21·060
	1,768·420

Out.

	Kg. Cal.
1 m³ producer gas, latent heat of same	1,333·900
Sensible heat of same after deducting radiation and convection losses, sensible heat, loss in ash, &c.	243·110
Heat value of steam contained in gas total moisture per m³ = 0·05185 kg., leaving the producer at 785 deg. C:	
	Kg. Cl.
A. Water value at 100 deg. C. =	5·185
B. Latent heat	27·840
C. Superheat	17·080
	50·105
	1,627·115

Thermal efficiency of producer:

$$\frac{1{,}627{\cdot}115 \times 100}{1{,}768{\cdot}420} = 91{\cdot}25 \text{ per cent.}$$

Heat available for carbonising purposes per m³ producer gas:

	Kg. Cal.
Gas outlet temperature from retort = 120 deg. C. = 248 deg. F.	
Amount of sensible heat carried by 1 m³ gas at 785 deg. C., plus superheat of steam =	260·19
Amount of sensible heat carried by 1 m³ gas at 120 deg. C.	37·20
Total heat available for carbonising per m³ gas	222·99

Some years ago Börnstein made a series of experiments in order to ascertain what took place, purely from a mechanical point of view, when coal was distilled, and he found that heating up to certain temperatures gave the following results:

100 deg. to 110 deg. C. evaporation of free moisture.
200 deg. C. commencement of driving-off combined water.
200 deg. to 250 deg. C. first traces of oil vapours produced.
250 deg. to 300 deg. C. most of combined water expelled.
325 deg. to 400 deg. C. distillation proceeding.
350 deg. to 400 deg. C. first traces of combustible gas evolved.
375 deg. to 420 deg. C. commencement of quick gas evolution.
280 deg. to 300 deg. C. first traces of dissociation of organic sulphur compounds.

It is a well-known fact that the low-temperature gas has a very high heating value, some very recent Continental investigators place the British thermal unit value at 800 B.Th.U. per cubic foot after oil scrubbing, and as high as 1,050 B.Th.U. per cubic foot before scrubbing, and there is no reason to doubt the reliability of these statements.

It is also claimed very recently by Thyssen that the low-temperature gas after oil scrubbing is of not less than 750 B.Th.U. per cubic foot.

Low-temperature gas distilled from bituminous coals as mentioned above, at a temperature not exceeding 550 deg. to 600 deg. C. (*i.e.*, the temperature to which the actual coal was heated up) and a distillation period not exceeding 2½ hours to 3 hours, produces a low-temperature gas of the following average composition:—

	Per Cent.	
CO_2	3·8	Heating value per m³ = 6,500 kg. cal. corresponding to just over 735 B.Th.U. per cub. ft.
CnHm	8·0	
CO	4·5	
CH_4	61·6	
H_2	17·3	
O_2	1·0	
N_2	3·8	
	100·0	

The amount of gas evolved per ton of the above coals is roughly 140 m³, corresponding to 4,900 cub. ft., and the heat of formation from the analysis of the gas should be about 380 kg. cal. per m³, which should assist in the carbonising, if this amount, according to D. D. Barnum, was not set off by the decomposition heat of the coal. It will, therefore be advisable to neglect this amount of heat altogether, it is at any rate slightly higher than the decomposition heat of the coal.

The amount of heat required to distil 1 ton of the above coal at 550 deg. to 600 deg. C. is, according to tests carried out by Mr. Nielsen, about 180,000 kg. cal., or 2·85 per cent. on total heating value of the raw coal, after making allowance for losses.

The total radiation and convection losses from the rotary retort when provided with 9-in. firebrick lining plus a 3-in. insulating brick, and insulating the outer steel shell so that the outside skin mean temperature does not exceed 40 deg. C., is round 20,000 kg. cal. per ton of coal carbonised, this loss represents 0·315 per cent. on the total heating value of the coal.

Amount of producer gas required to carbonise 1 ton of raw coal:—

$$\frac{180{\cdot}000 + 20{\cdot}000}{222{\cdot}9 \text{ kg. cal.}} = 900 \text{ m}^3 \text{ producer gas at 785 deg. C. (reduced to 0 deg. C.).}$$

Corresponding amount of semi-coke to be gasified:—

$$\frac{900 \text{ m}^3}{3{\cdot}81 \text{ m}^3 \text{ per kg. coke}} = 0{\cdot}236 \text{ ton of semi-coke.}$$

Amount of coke produced per ton of raw coal, 0·735 ton.

Amount of coke available for complete gasification in producers after deducting producer requirements per ton of coal carbonised:—

$$0{\cdot}735 - 0{\cdot}236 = 0{\cdot}499 \text{ ton.}$$

Total gas produced per ton of raw coal:

	M³.
A. From low-temperature carbonising	140
B. From producer, effecting carbonising	900
C. From producers dealing with balance of semi-coke, 0·499 ton	1,900
Total volume of mixed gas =	2,940

Corresponding to about 103·000 cub. ft.

Average composition of mixed gas:

	Per Cent.
CO_2	5·89
CO	24·51
CH_4	5·45
CnHm	0·38
H_2	13·68
O_2	0·42
N_2	49·67
	100·00

Total combustibles in gas: 44 per cent.

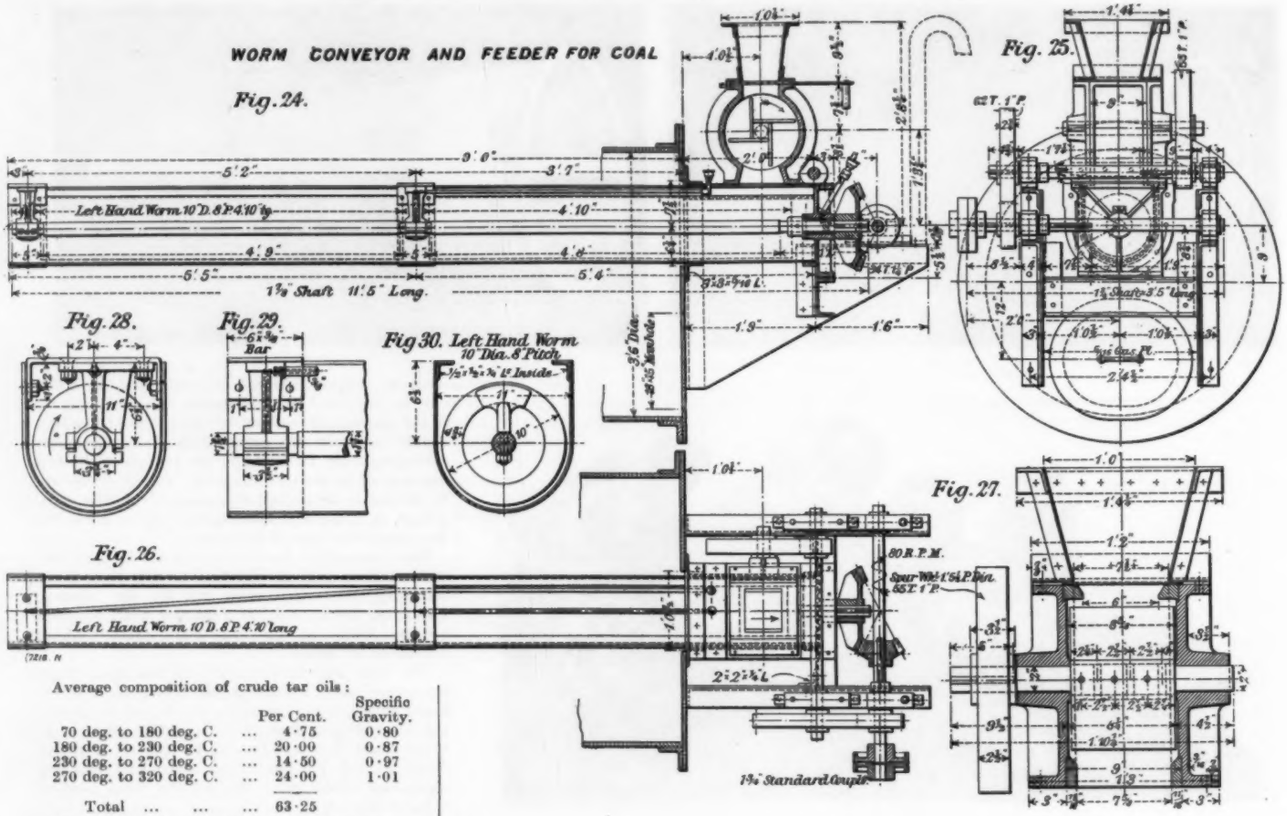
Net heating value of gas per m³ at N.P.T. = 1,600 kg. cal., corresponding to 180 B.Th.U. per cubic foot. Total kg. cals. recovered in gas = 4,700,000 kg. cal. per ton of raw coal.

Tar oils recovered per ton of raw coal:—

18 gallons at 16,000 B.Th.U. per lb., corresponding to 81 kg. at 9,000 kg. cal. per kg. = 729,000 kg. cal., equivalent in weight to 8·1 per cent. on raw coal.
Average specific gravity of crude tar oils at 15 deg. C. = 1·076.

LOW TEMPERATURE ROTARY CARBONISATION PLANT.

SENSIBLE HEAT DISTILLATION, LIMITED, ENGINEERS, LONDON.


WORM CONVEYOR AND FEEDER FOR COAL
Fig. 24.
Left Hand Worm 10 D. 8 P. 4'10" lg.
1⅞" Shaft 11'5" Long.
Fig. 25.
Fig. 28.
Fig. 29.
Fig. 30. Left Hand Worm 10 Dia. 8 Pitch
Fig. 26.
Left Hand Worm 10 D. 8 P. 4'10 Long
Fig. 27.
80 R.P.M.
14" Standard Angle

Average composition of crude tar oils:

	Per Cent.	Specific Gravity.
70 deg. to 180 deg. C. ...	4·75	0·80
180 deg. to 230 deg. C. ...	20·00	0·87
230 deg. to 270 deg. C. ...	14·50	0·97
270 deg. to 320 deg. C. ...	24·00	1·01
Total	63·25	

Residue: Hard pitch loss = 36·75 per cent. by dry distillation.

Neutral oils soluble in petrols, 52 per cent. by volume.

Phenols oils soluble in petrols, 20 per cent. by volume.

Insoluble in petrol, 28 per cent. by volume.

The neutral oils show no sign of decomposition at 400 deg. C.

Heat recovered in tubular waste heat boilers, linked up to hot gas outlet at producers, gasifying balance of semi-coke.

Temperature of hot gas, entering boilers, 560 deg. C.
Temperature of hot gas, leaving boilers, 250 deg. C.

Amount of heat converted into steam: 193,000 kg. cal., corresponding to about 370 kg. steam raised from and at 100 deg. C. at 4 atm. pressure.

Net steam raising efficiency: About 60 per cent.

The above amount of steam corresponds closely to the total steam requirements of the operating producers.

Utilising the sensible heat of the producer gas as it leaves the waste heat boilers at 250 deg. C. in tubular feed-water heaters, the feed water is raised to boiling-point, so it will be clear that as far as steam requirements are concerned, the plant is self-contained and does not require any outside supply for the process.

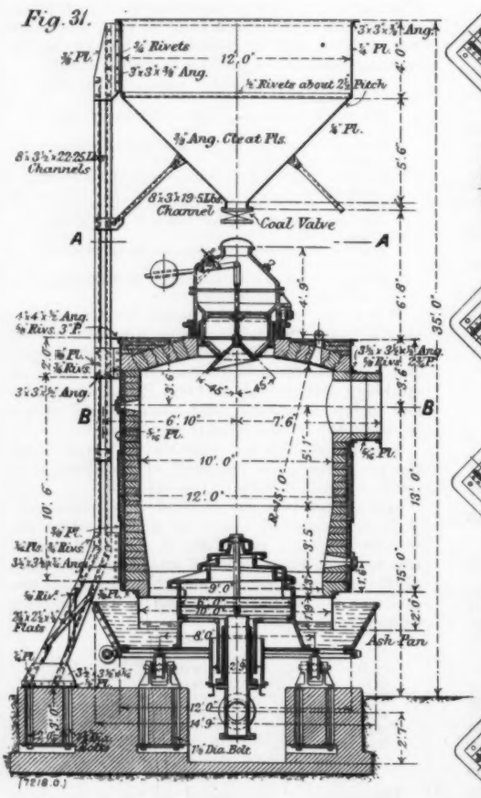
Total net thermal efficiency of combined processes:—

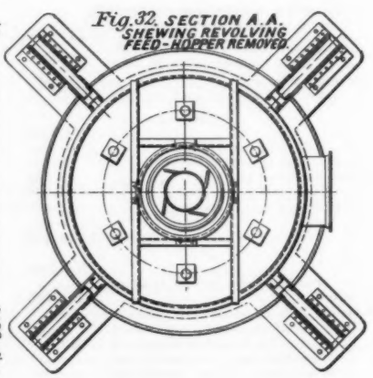
		Kg. Cal.
In.		
1 ton of raw coal		6,333,000
Out.		
Gas, net heating value		4,700,000
Tar oils		729,000
		5,429,000

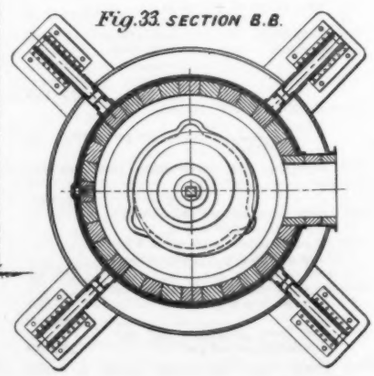
Efficiency $\frac{5,429,000}{6,333,000}$ = 85·6 per cent.

NOTE.—Regarding sulphate recovery.

As the producers are not run under by-product conditions, that is to say, for the maximum yield of sulphate, it is very doubtful whether it would

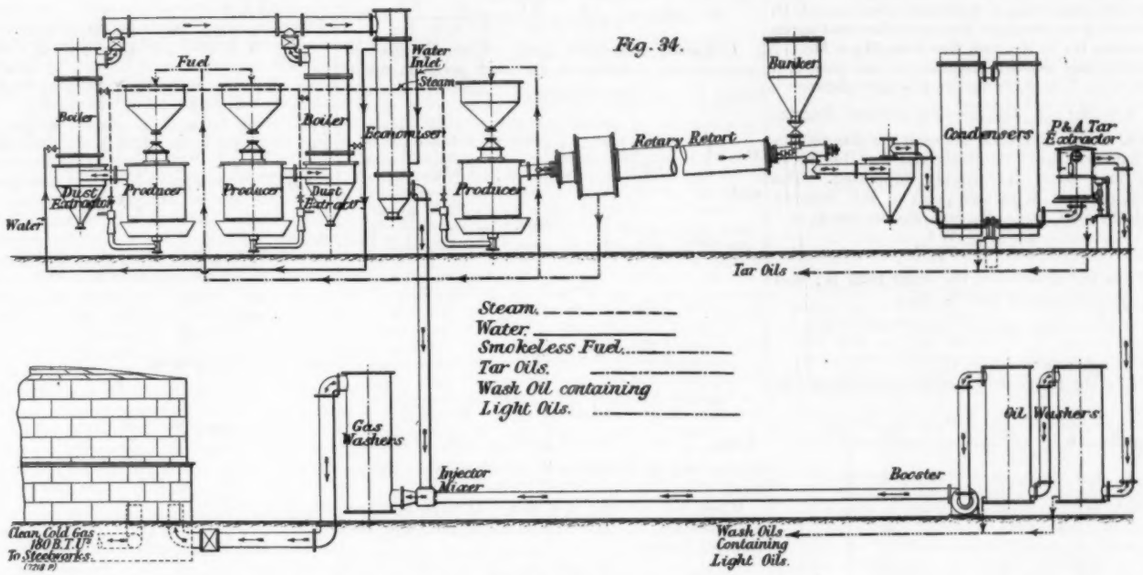






ARRANGEMENT OF PRODUCER GAS PLANT WITH ROTARY RETORT.

SENSIBLE HEAT DISTILLATION, LIMITED, ENGINEERS, LONDON.



pay to recover the small amount involved, a maximum of 15 lb. to 20 lb. per ton of coal treated by the combined process. If the gas was not specifically required for steel furnaces, but for power plant purposes, the aspect would naturally become quite different.

STATICALLY INDETERMINATE AND NON-ARTICULATED STRUCTURES.

By Professor F. C. LEA, D.Sc., M.Inst.C.E., M.Inst.Mech.E.. M.I.M., A.R.C.S., Wh.Sc.

(*Continued from page* 315.)

GIRDER CONNECTED TO TWO COLUMNS, FIG. 6, WHICH ARE RIGIDLY FIXED IN THE GROUND.

This is another case that frequently arises in designing reinforced concrete buildings. The main transverse girders are rigidly fixed to the columns and the longitudinal girders are carried on the main

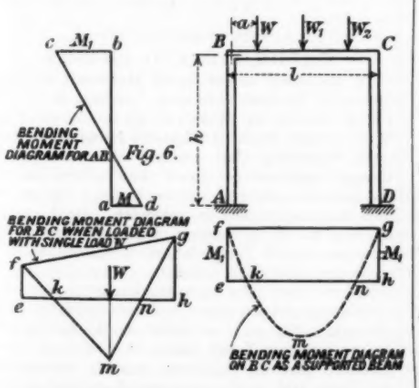

BENDING MOMENT DIAGRAM FOR A B
BENDING MOMENT DIAGRAM FOR B C WHEN LOADED WITH SINGLE LOAD W.
BENDING MOMENT DIAGRAM ON B C AS A SUPPORTED BEAM

Fig. 6.

girders. When the load is assumed uniformly distributed, or the loads on B C are symmetrically placed, the structure is symmetrical, and the couples at B and C are equal, and also at A and D. The bending moment diagram for B C is $e\,f\,k\,m\,n\,g\,h$ (Fig. 6), made up of the difference between the moment diagram due to the end couples M_1 and the diagram of bending moments for the loads. Since there is no external load on A B it can be considered as acted upon by couples M and M_1 at its extremities and the bending moment diagram is $a\,b\,c\,d$. As a simple case consider first a uniformly distributed load on A B. Then the total work done by flexure is :

$$U = 2\int_0^h \left\{ M - (M - M_1)\frac{x}{h} \right\}^2 \frac{dx}{2EI} + 2\int_0^{\frac{l}{2}} \left(- M_1 - \frac{w\,l}{2}\,x + \frac{a\,x^2}{2} \right)^2 \frac{d\,x}{2\,E\,I_0}$$

$$\frac{d\,U}{d\,M} = 0 = \frac{M\,h}{3\,I} + \frac{M_1\,h}{6\,I} \qquad \therefore M = -\tfrac{1}{2}M_1$$

$$\frac{d\,U}{d\,M_1} = \frac{M_1\,h}{3\,I} + \frac{M\,h}{6\,I} + \frac{1}{I_0}\int_0^{\frac{l}{2}} M_1\,x + \frac{w\,l\,x^2}{4} - \frac{a\,x^3}{6} = \frac{M_1\,h}{3\,I} + \frac{M\,h}{6\,I} + \frac{1}{I_0}\left(M_1\frac{l}{2} + \frac{w\,l^3}{24} \right) = 0$$

Let

$$\frac{I_0}{l} \times \frac{h}{I} = r$$

then

$$\frac{M_1}{3} - \frac{M_1}{12} + \frac{1}{r}\left(\frac{M_1}{2}\right) + \frac{w\,l^2}{24\,r} = 0$$

$$\frac{M_1}{4} + \frac{M_1}{2\,r} = -\frac{w\,l^2}{24\,r}$$

$$M_1\left(\frac{1}{4} + \frac{1}{2\,r}\right) = -\frac{w\,l^2}{24\,r}$$

$$M_1\left(\frac{r+2}{4\,r}\right) = \frac{w\,l^2}{24\,r}$$

$$M_1 = \frac{-2}{2+r}\left(\frac{w\,l^2}{12}\right)$$

and

$$M = \frac{1}{2+r}\,\frac{w\,l^2}{12}$$

Similarly if there is a concentrated load W_1 at the centre of the girder

$$M_1 = \frac{-2}{2+r}\,\frac{W_1\,l}{8}$$

and

$$M = \frac{1}{2+r}\,\frac{W\,l}{8}$$

Concentrated load W at any point on B C.

At the points A, B, C, D, there are couples M_A, M_B, M_C and M_D acting, as already seen, when the load W is in the centre of B C, the couple $M_A = M_D$ and $M_B = M_C$. The bending moment diagram for B C is $e\,f\,g\,h\,k$, and the bending moment diagram for A B is $a\,b\,c\,d$

Let I = moment of inertia of B C, and I_0 = moment of inertia of A B. Let

$$\frac{I}{I} \times \frac{I_0}{h} = r$$

The total work done on the structure, when W is at any point on B C, is then

$$U = \int_0^h \left\{ M_{AB} - (M_{AB} - M_{BA})\frac{x}{l} \right\}^2 \frac{dx}{2\,E\,I_0} + \int_0^h \left\{ M_{DC} - (M_{DC} - M_{CD})\frac{x}{l} \right\}^2 \frac{dx}{2\,E\,I_0} + \int_0^a \left\{ M_{BC} - (M_{BC} - M_{CB})\frac{x}{l} - \frac{W\,b\,x}{l} \right\}^2 \frac{dx}{2\,E\,I} + \int_0^b \left\{ M_{CB} - (M_{CB} - M_{BC})\frac{x}{l} - \frac{W\,a\,x}{l} \right\}^2 \frac{dx}{2\,E\,I}$$

From the figure it is seen that by giving proper signs to the couples

$$M_{AB} + M_{BC} + M_{CD} + M_{DC} = 0$$

By substituting in the equations and differentiating with respect to three variables, three equations are obtained, from which the following results for the couples are obtained :

$$M_{AB} = \frac{(7r+3)}{2(r+2)(6r+1)}\,\frac{W\,a^2 b}{l^2} + \frac{(5r-1)}{2(r+2)(6r+1)}\,\frac{W\,a\,b^2}{l^2} \quad . \quad . \quad . \quad (5)$$

$$M_{DC} = \frac{5r-1}{2(r+2)(6r+1)}\,\frac{W\,a^2 b}{l^2} + \frac{(7r+3)}{2(r+2)(6r+1)}\,\frac{W\,a\,b^2}{l^2} \quad . \quad . \quad (6)$$

$$M_{CB} = -\frac{(13r+4)}{2(r+2)(6r+1)}\,\frac{W\,a^2 b}{l^2} - \frac{11r}{2(r+2)(6r+1)}\,\frac{W\,a\,b^2}{l^2} \quad . \quad . \quad . \quad (7)$$

$$M_{BC} = -\frac{11r}{2(r+2)(6r+1)}\,\frac{W\,a^2 b}{l^2} - \frac{(13r+4)}{2(r+2)(6r+1)}\,\frac{W\,a\,b^2}{l^2} \quad . \quad . \quad . \quad (8)$$

The horizontal thrust H at A and B

$$= \frac{1}{h}\left\{\frac{3}{2(r+2)}\right\}\left\{\frac{W\,a^2 b}{l^2} + \frac{W\,a\,b^2}{l^2}\right\} \quad . \quad (9)$$

When

$$a = b = \frac{l}{2}$$

$$M_{AB} = M_{DC}\,\frac{7r+3+5r-1}{2(r+2)(6r+1}\,\frac{W\,l}{8} = \frac{1}{2+r}\,\frac{W\,l}{0{\cdot}8}$$

and

$$M_{BC} = M_{CB} = -\frac{11r+13r+4}{2(r+2)(6r+1}\,\frac{W\,l}{8} = -\frac{2}{2+r}\,\frac{W\,l}{8}$$

which agree with the results already obtained.

TWO COLUMNS HINGED AT THE FOUNDATION, FIG. 7, AND RIGIDLY CONNECTED BY A BEAM.

Consider any load W at any point on the beam. Since the columns are hinged at A and D there are

no couples at these points. There are, however, couples M_B and M_C acting at B and C respectively.

The couple acting at B on B A clearly introduces a horizontal reaction at A and the couple acting at C on C D introduces a horizontal reaction at D, since there is no resultant horizontal force acting on the system, $H_A = H_D$ and, therefore, $M_B = M_C$.

The bending moment diagram on the post A B is $a\,b\,c$, Fig. 7, and the moment at any distance x from A is $M_B \cdot \frac{x}{h}$. The bending moment diagram for B C is the difference between the diagram for the "indeterminate" moments and that due to W acting on a beam B C simply supported. The bending moment M at any point in B C between B and the load, since M_B and M_C are equal, is

$$M = M_B - \frac{W\,b}{l}x,$$

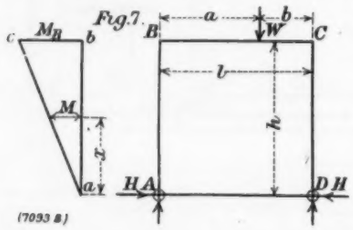
where x is the distance of the point from B; and at any point between C and the load,

$$M = M_B - \frac{W\,a}{l} \cdot x,$$

x now being measured from C.

Let I be the moment of inertia of the horizontal

Fig. 7.



section of each of the vertical posts and I_0 the moment of inertia of the vertical section of the beam B C.

Then the energy stored in the system is:

$$U = \int_0^h \frac{\left(-M_B\frac{x}{h}\right)^2 dx}{2EI} + \int_0^h \frac{\left(-M_C\frac{x}{h}\right)^2 dx}{2EI} + \int_0^a \frac{\left\{M_B - (M_B - M_C)\frac{x}{h} - \frac{W\,b\,x}{l}\right\}^2 dx}{2EI_0} + \int_0^b \frac{\left\{M_C - (M_C - M_B)\frac{x}{h} - \frac{W\,a\,x}{l}\right\}^2 dx}{2EI_0} \quad (1)$$

or, since $M_B = M_C$

$$U = 2\int_0^h \frac{\left(-M_B\cdot\frac{x}{h}\right)^2 dx}{2EI} + \int_0^a \frac{\left(M_B - \frac{W\,a\,x}{l}\right)^2 dx}{2EI_0} + \int_0^b \frac{\left(M_B - \frac{W\,a\,x}{l}\right)^2 dx}{2EI_0} \quad . \quad . \quad . \quad . \quad (2)$$

Then

$$\frac{dU}{dM_B} = 2\int_0^h \frac{M_B\cdot\frac{x^2}{h^2}dx}{I} + \int_0^a \frac{\left(M_B - \frac{W\,a\,x}{l}\right)dx}{I_0} + \int_0^b \frac{\left(M_B - \frac{W\,a\,x}{l}\right)dx}{I_0} = 0 \quad . \quad (3)$$

or

$$2\left[{}_0^h + M_B\frac{x^3}{3h^2}\right] + \left[{}_0^l \frac{M\cdot x}{I_0}\right] - \left[{}_0^a \frac{W\,b\,x^2}{2\,l\,I_0}\right] - \left[{}_0^b \frac{W\,a\,x^2}{2\,l\,I_0}\right] = 0 \quad . \quad . \quad (4)$$

i.e.,

$$\frac{2}{3}\cdot\frac{M_B\cdot h}{I} + \frac{M_B\cdot l}{I_0} - \left(\frac{W\,b\,a^2}{2\,l\,I_0} + \frac{W\,a\,b^2}{2\,l\,I_0}\right) = 0 \quad . \quad (5)$$

Let $\frac{I_0}{l} \times \frac{h}{I} = r$ and let each term in the right hand bracket be multiplied by l.

Then

$$\frac{2}{3}M_B + \frac{M_B}{r} - \frac{W\,a\,b}{2\,l\,r} = 0 \quad . \quad . \quad (6)$$

or

$$M_B = \frac{3\,W\,a\,b}{2\,(2r+3)} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

or

$$M_B = \frac{3}{2\,(2r+3)}\left(\frac{W\,b\,a^2}{l^2} + \frac{W\,a\,b^2}{l^2}\right) \quad . \quad (8)$$

But $\frac{W\,b\,a^2}{l^2}$ and $\frac{W\,a\,b^2}{l^2}$ would be the bending moment at C and B respectively if the beam B C were rigidly fixed at the ends.

When the load W is at the centre of B C, or $a = b$,

$$M_B = M_C = \frac{3}{2\,(2\,r+3)}\cdot\frac{W\,l}{4} = \frac{3}{(2\,r+3)}\cdot\frac{W\,l}{8} \quad (9)$$

Uniformly Distributed Load.—When the load W is uniformly distributed, the load per foot run w being $\frac{W}{l}$, equation (2) becomes

$$U = 2\int_0^h \frac{-M_B\left(\frac{x}{h}\right)^2 dx}{2EI} + 2\int_0^{\frac{l}{2}} \frac{\left(M_B - \frac{W}{2}x + \frac{W}{l}\cdot\frac{x^2}{2}\right)^2 dx}{2EI_0}$$

and

$$\frac{dU}{dM_B} = 2\left[{}_0^h \frac{M_B\,x^3}{I.\,3h^2}\right] + 2\left[{}_0^{\frac{l}{2}} \frac{M_B\,x - \frac{W}{2}\cdot\frac{x^2}{2} + \frac{W}{l}\cdot\frac{x^3}{6}}{I_0}\right] = 0$$

$$= \frac{1}{3}M_B\,\frac{h}{I} + \frac{M_B\frac{l}{2} - \frac{W}{2}\cdot\frac{l^2}{8} + \frac{W}{l}\cdot\frac{l^3}{48}}{I_0}$$

$$= \frac{1}{3}M_B + \frac{M_B}{2r} - \frac{W\,l}{24\,r}$$

or

$$M_B = \frac{3}{2\,(2\,r+3)}\left(\frac{W\,l}{12}\right) = \frac{W\,l}{8\,(2r+3)} = \frac{w\,l^2}{8\,(2r+3)}$$

Again $\frac{W\,l}{12} = \frac{w\,l^2}{12}$ is the bending that would act at the end of the beam if the beam were rigidly fixed.

When the columns A B and C D have not the same section, let I_1 be the moment inertia of the column C D, and

$$\frac{h}{I_1} \times \frac{I_0}{l} = p$$

then

$$M_B = \frac{3\,W}{2\,(r+p+3)\,l^2}\left(a^2\,b + a\,b^2\right)$$

for a concentrated load W and

$$M_B = \frac{3}{2\,(r+p+3)}\cdot\frac{w\,l^2}{12}$$

for a uniformly distributed load of w per foot run.

TWO STOREY BUILDING, FIGS. 8 AND 9, WITH BEAMS ATTACHED TO COLUMNS.

$$U = 2\int_0^{h_1}\left\{M - (M - M_1)\frac{x}{h_1}\right\}^2 \frac{dx}{2EI_1} + 2\int_0^h \left\{M_3 - (M_3 - M_4)\frac{x}{h}\right\}^2 \frac{dx}{2EI} + 2\int_0^l \left(M_2 - \frac{w_1\,l}{2}x + \frac{w_1\,x^2}{2}\right)^2 \frac{dx}{2EI_0} + 2\int_0^l \left\{M_5 - \frac{w\,l}{2}x + \frac{w\,x^2}{2}\right\}^2 \frac{dx}{2EI_2} \quad . \quad (1)$$

$$M_1 + M_3 = M_2 \quad . \quad . \quad . \quad (2)$$

$$M_4 = -M_5 \quad . \quad . \quad . \quad (3)$$

Fig. 8.

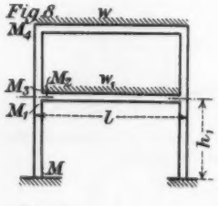
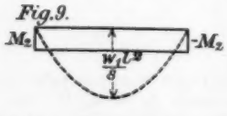


Fig. 9.



$$U = 2\int_0^{h_1}\left\{M - (M - M_1)\frac{x}{h_1}\right\}^2 \frac{dx}{2EI_1} + 2\int_0^h \left\{M_3 - (M_3 - M_4)\frac{x}{h}\right\}^2 \frac{dx}{2EI} + 2\int_0^l \left\{(M_2 + M_5) - \frac{w_1\,l\,x}{2} + \frac{w\,x^2}{2}\right\}^2 \frac{dx}{2EI_0} + 2\int_0^l \left(-M_4 - \frac{w\,l}{2}x + \frac{w\,x^2}{2}\right)^2 \frac{dx}{2EI_2} \quad (4)$$

$$\frac{dU}{dM} = \frac{1}{I_1}\left(\frac{M\,h_1}{3} + \frac{M_1\,h_1}{6}\right) + 0 \quad . \quad . \quad (5)$$

$$= \frac{1}{\left(\frac{I_1}{h_1}\right)}\left\{\frac{M}{3} + \frac{M_1}{6}\right\} = 0 \qquad \frac{I_0}{h} \times \frac{h}{I_1} = r \quad (6)$$

$$\frac{dU}{dM_1} = \frac{1}{I_1}\left(\frac{M\,h_1}{6} + \frac{M_1}{3}\right) + \frac{1}{I_0}\left\{\frac{M_1\,l}{2} + \frac{M_3\,l}{2} + \frac{w_1\,l^3}{24}\right\} = 0$$

or

$$\frac{M}{6} + \frac{M_1}{3} + \frac{M_1}{2r} + \frac{M_3}{2r} + \frac{w_1\,l^2}{24\,r} = 0 \quad . \quad . \quad (7)$$

$$\frac{dU}{dM_3} = \frac{M_3}{3\left(\frac{I}{h}\right)} + \frac{M_4}{6\,\frac{I}{h}} + \frac{1}{I_0}\left\{\frac{M_1}{2} + \frac{M_3}{2} + \frac{w_1\,l^2}{24}\right\}\frac{1}{l} = 0$$

Let

$$\frac{I_0}{l} \times \frac{h}{I} = q$$

then

$$\frac{M_3}{3} + \frac{M_4}{6} + \frac{M_1}{2\,q} + \frac{M_3}{2\,q} + \frac{w_1\,l^2}{24\,q} = 0 \quad . \quad (8$$

$$\frac{dU}{dM_4} = \frac{M_3}{6\,\frac{I}{h}} + \frac{M_4}{3\,\frac{I}{h}} + \frac{1}{I_2}\left(\frac{M_4}{2} + \frac{w\,l^2}{24}\right) \quad . \quad (9)$$

from which by making

$$\frac{I_2}{l} \times \frac{h}{I} = p$$

$$\frac{M_3}{6} + \frac{M_4}{3} + \frac{M_4}{2\,p} + \frac{w\,l}{24\,p_1} = 0$$

or

$$\frac{M_3}{3} + M_4\left(\frac{2\,p+3}{3\,p}\right) + \frac{w\,l^2}{12\,p} = 0 \quad . \quad (10)$$

From (7):

$$M_1\left(\frac{2\,r+3}{3\,r}\right) + \frac{M}{3} + \frac{M_3}{r} + \frac{w\,l^2}{12\,r} = 0 \quad . \quad (11)$$

From (6):

$$M = -\tfrac{1}{2}M_1 \quad . \quad . \quad . \quad (12)$$

From (8):

$$\tfrac{2}{3}M_3 + \frac{M_4}{3} + \frac{M_1}{q} + \frac{M_3}{q} + \frac{w_1\,l^2}{12\,r} = 0 \quad . \quad (13)$$

Four equations from which to find M, M_1, M_2, M_3 and M_4:

$$M = -\frac{q\,(p+2)}{(p+2)\,(qr+2\,q+2\,r)-r}\cdot\frac{w_1\,l^2}{12} + \frac{q}{(p+2)\,(q\,r+2\,q+2r)-r}\cdot\frac{w\,l^2}{12}$$

Let

$$(p+q)\,(q\,r+2\,q+2\,r) - r = \mathrm{D}$$

$$M_1 = \frac{2\,q\,(p+2)}{\mathrm{D}}\cdot\frac{w_1\,l^2}{12} - \frac{2\,q}{\mathrm{D}}\cdot\frac{w\,l^2}{12}$$

$$M_2 = \frac{2\,(p+2)\,(q+2)+r}{\mathrm{D}}\cdot\frac{w_1\,l^2}{12} + \frac{q\,r}{\mathrm{D}}\cdot\frac{w\,l^2}{12}$$

$$M_3 = \frac{r\,(2\,p+3)}{\mathrm{D}}\cdot\frac{w_1\,l^2}{12} + \frac{q\,(r+2)}{\mathrm{D}}\cdot\frac{w\,l^2}{12}$$

$$M_4 = -\frac{r\,p}{\mathrm{D}}\cdot\frac{w_1\,l^2}{12} - \frac{2\,r\,q+4\,q+3\,r}{\mathrm{D}}\cdot\frac{w\,l^2}{12}$$

(To be continued.)

RADIOLOGY AND PHYSICS.

IN the course of the fourth Mackenzie Davidson Memorial Lecture, delivered last month to the Royal Society of Medicine, Dr. G. W. C. Kaye, M.A., of the National Physical Laboratory, dwelt upon something that we are all interested in, though engineers not more than others, namely, the need of a physical science training for medical men, and radiologists in particular. Dr. Kaye also referred to the protection of X-ray workers, the arrangement of X-ray laboratories, the needs of inspection, and of an Institute of Radiology.

But we must pass on to the lecturer's comments upon recent developments and tendencies in X-ray research. The sun, he stated, might be regarded as an immense X-ray bulb, the rays of which probably play an important part in atmospheric electricity and in the vagaries of radiotelegraphy. There may yet be unknown X-rays, on both sides of the known range. The unknown gap of four octaves, which was so far left between the shortest ultra violet light rays and the longest X-rays, has within the last few weeks been bridged over by means of indirect photo-electric methods, the wave-lengths concerned being too small for ruled gratings, but too big for crystal gratings. On the other hand, there is reason to believe that one more series of characteristic X-rays, the "J" series, exists, shorter than the K, L, M series which increase in wave-lengths in the order stated. X-rays then seem to cover a range of 13 octaves, from 500

Angström-units down to 0·06 A.U., and when we include the γ-rays, from 1·4 down to 0·01 A.U., we have 16 octaves. Thus the spectrum of the X-rays would with these inclusions actually overlap the ultraviolet and the γ-rays spectra, and that may appear strange. But as the ordinary spectrum of a hot body consists of a continuous spectrum of white light from which the characteristic lines of the element, *e.g.*, the D lines of sodium, flash out, so an element emitting X-rays not only gives a "white" radiation, but it superposes its characteristic rays of the K, L, M series upon the new spectrum, and the J series may, as above stated, have to be added to them.

Take the case of a bulb having a target of platinum. As the potential V applied to the terminals is raised, the amount of general white radiation increases proportionately to V^2. Further, at certain critical volts, a new series of lines will flash out, and the output and homogeneity of the beam are temporarily increased. The series, their exciting potentials in volts and the corresponding wave lengths in A.U., would be the following: Series M, L, K, J; volts 2,500, 13,000, 75,000, 180,000 and more; A.U., 5·2, 0·96, 0·17, 0·07. The J series being doubtful has been calculated from Moseley's law. In the case of tungsten, which has a lower atomic weight than platinum (184 against 197·2), the existing volts are smaller (in the ratio of the squares of the atomic weights); they range from 2,000 up to 160,000.

To excite these J-rays, special bulbs able to bear potentials of 200,000 volts will have to be designed. Transformers for 1,000,000 volts are said to have already been constructed by Coolidge, and the special X-ray bulbs just mentioned will no doubt be produced. So far the radiologist practically only makes use of the K series and the general radiation; the L and M rays hardly penetrate through the glass. Recent researches also promise to supply radiologists with a better scale of ray-quality than they possess at present. There is a definite boundary (or quantum limit) to every spectrum of general X-rays on the short-wave side, and this boundary depends only upon the maximum volts, not upon the target metal in the bulb. This relation is $Ve = h\nu$ where V is the maximum potential applied, ν the frequency of the shortest wave λ_0, e the electronic charge and h Planck's constant. From this relation we obtain $V = 12{,}400/\lambda_0$. We can now either deduce this shortest λ_0 from the maximum volts V, or we can base our calculations upon a measurement of the quantum limit. The latter is effected by means of the direct-reading spectrometer of Seemann. In one of these instruments a crystal of rock salt is joined to a piece of lead in such a way that the two form a continuous horizontal slab; underneath the junction is placed a vertical wedge of lead, leaving a very narrow slit between the slab and the wedge. The rays fall at grazing incidence on the crystal and are refracted on to the photographic plate; the obtuse angle of 150 or 170 deg. of the wedge of lead or tungsten, etc., stops stray rays so that the quantum limit of the least-deviated rays can sharply be determined.

When the X-rays pass through a material, they are partly absorbed and partly scattered. The absorbed rays are transformed into the characteristic rays of the material under examination, the scattered rays are the unaltered rays received, but changed as to direction. Scattering is analogous to light diffusion by a fog; it is more pronounced with light atoms than with heavy atoms, but like absorption it increases with the closeness of the packing of the atoms. According to Dr. Kaye we may assume that absorption is caused by the flicking off, by the X-ray, of an electron in one of the electronic ring systems of the atom, and the prompt replacement of the electron from the next ring further out, which is similarly replaced in its turn. The system then expels an electron and vibrates with characteristic periods; we can generate the L series without generating the K series, but not *vice versa*. When the X-ray is incapable of actually ejecting an electron, but can merely jar it, then the electron, having absorbed the energy of the X-ray, vibrates, not with its own period but with a forced period prescribed by the X-ray, and re-emits its energy in all directions. The study of scattering has become of great importance, and it is receiving full attention at the National Physical Laboratory and elsewhere.

NOTES ON NEW BOOKS.

A good textbook is signalised by the soundness of its selection from the work of specialists and its unification with the author's own contributions into a reasoned whole. In consequence there is an obligation of the most scrupulous honesty of acknowledgment. This honourable standard is flouted in a textbook entitled "*Calcul des Avions*" which we have received from its publishers, the well-known firm of Gauthier-Villars and Co., 55, Quai des Grands-Augustins Paris [price 30 fr.], and having the name as author of M. Boilève, who bears the responsible title of *Professeur à l'Ecole Supérieure d'Aéronautique*. The language is French, the curves and diagrams are re-drawn to different scales, sometimes inverted, sometimes perverted, but substantially the book is an adaptation where it is not a close translation of Pippard and Pritchard's well-known "Aeroplane Structures," reviewed in ENGINEERING, March, 5, 1920, page 299. Other British writers, duly quoted by these authors, are re-quoted by M. Boilève, sometimes with slight and totally inadequate acknowledgment but generally with none. Mr. Case's contributions to "Aeronautics" are thus treated but his name is at least mentioned. Mr. Webb's highly original work on struts is reproduced without a hint of indebtedness. Berry's important work on Booth and Bolas' extension of the theorem of three moments, and the complete tables of "Berry" functions which make it a design room method, are transferred bodily without the slightest reference. Pages 189-199 are wholly taken from Berry and Garner's paper, A.C.A. Reports, 1917-8, page 894 *et seq.*, unacknowledged. A variation of this easy method is found on page 109, Fig. 79, and page 110, where a summary of an American report with a judicious selection of six out of fourteen types of wire loops appears with the same original comments, as in Pippard and Pritchard's "Handbook of Strength Calculations," issued by the Air Ministry. At the same time reference is artfully given to the original report which M. Boilève had evidently never seen. On page 112 a piece of early work given on page 118 of the "Handbook" and due for revision by the authors, is uncritically transferred, analysis and all, without a hint of its source. Boilève's Fig. 123 is taken from Pippard's Fig. 122—pages 204-8 from Pippard, "Aeronautics," April 24, 1919, page 246—Figs. 145-158 from Figs. 131-145 with slight variations in the order. It might be possible to explain away an individual case, but the cumulative proof is overwhelming. Chapters 13 and 14 of "Aeroplane Structures" have simply been translated without acknowledgment, and even the sincere flattery implied will scarcely bring the chief victims to appreciate the sardonic humour of the note on the reverse of the title page—"All rights of translation, of reproduction and of adaptation, for all countries, are reserved." The nominal author has evidently imposed a belief in his right to authorship on the publishers. Their high reputation demands the withdrawal of the present edition and its re-issue with the permission of the real authors and with their names on the title page.

Few people will deny nowadays the value of reinforced concrete construction, though many hesitate to acknowledge all of the many claims which have at one time and another been made for this material. Of course, failures have at times been known, but in an engineering sense a failure is only relative. For instance, there have been many failures of steam turbines, yet no one would dream for that reason of condemning all machinery of that type; rather the non-successes have led to investigations which have resulted in enhanced reliance being possible with the products of improved design and first-class workmanship of approved firms. The same may be said of reinforced concrete; the faulty design of people who did not understand its essential principles, or bad workmanship, can both now be easily avoided with care. The wide range of work to which these principles of construction are applicable is well shown in a volume entitled "*Mouchel-Hennibique Ferro-Concrete*," and published at the price of 21*s.* net by Messrs. L. G. Mouchel and Partners, Limited, 36 to 38, Victoria-street, S.W. 1. This work is now in its fourth edition. It is a book of over 500 pages, of which the first 100 or so are devoted to a discussion of the Hennebique system of reinforcement, the remainder being devoted to a pictorial review of a very large number of successful works, some of which have at one time and another been noticed in our columns. The first part of the book deals with a number of practical points, such as rapidity of construction, watertightness, durability, impermeability, resistance to vibration, fire resistance, &c., and contains a quantity of interesting data backed by experience of work carefully executed. To anyone who has not followed the progress made by this type of construction the book will be instructively interesting owing to the variety and number of the works illustrated, which include buildings of all types, bridges, marine structures, tanks, baths, coal bunkers, and others.

An interesting and very readable book on Petroleum, written in the French language, "*Les Gisements de Pétrole*," by Mr. J. Chautard, has recently been issued by Mr. G. Doin, 8, Place de l'Odéon, Paris, 6. It deals with the analysis and other characteristic features of petroleum, natural gases and bitumen, and states that the problem as to whether petroleum is of organic or inorganic origin remains so far unsolved. On the other hand, the formation of modern hydrocarbons, together with observations carried out in regard to the geology of petrol-bearing basins, do not yield any evidence in favour of the theory by which petroleum is ascribed an inorganic origin, whilst they yield quite a series of data in favour of the organic origin of petroleum or, more correctly, of bitumen; the bitumen, which in certain cases is transformed into petroleum, appears to proceed from a "raw material" of the animal kingdom chiefly, and only occasionally of the vegetable kingdom. The various petrol-bearing regions of the world are reviewed in detail; other chapters deal with soundings and the working of petroleum sources and wells. The book will be found a welcome addition to the "Encyclopédie Scientifique" series. Its price is 14 francs.

Books on steel structures are not rare, but they are not always of the general superior style and so well illustrated as the "*Eisenkonstruktionen*," of Professor L. Geusen, of Dortmund. The third edition of this work, published by Julius Springer, of Berlin, at the price of 384 marks (for England), forms a small quarto volume of 282 pages with 522 text figures and 2 coloured plates. These two plates are printed in black and red in order to facilitate the distinction of the members of movable joints. Professor Geusen has particularly been anxious to assist the young engineer in passing from structures practically of two dimensions to three-dimensional problems. The volume is intended for the use of designers, technical schools and of the drawing office; 89 problems are worked out. In general the volume may remind engineers of books of the type of the "Roofs and Bridges" of Merriman and Jacoby. Professor Geusen deals in his first section with structural elements, with girders, trusses, columns &c., and their construction, and in the second section with the construction of roofs and ceilings; the third section discusses bridges for railways and for urban traffic. The illustrations of complex structures are not merely diagrams; dimensions are given, and the detail is sufficient to guide the designer. Professor Geusen had, in 1915, based a text book on iron structures on the first edition of this work.

"When the half-gods go the gods arrive," says Emerson, and there are distinct indications that the authority of the little tin gods on whom labour has of recent years relied for guidance in social and economic questions, is being seriously challenged. The theory that profits were inherently iniquitous, and that large profits were merely sweated out of the workman's wages, no longer enjoys its former popularity, and labour leaders are occasionally admitting that both capital and the capitalist have their uses, though in spite of the failure of the co-operative societies to establish a single new industry, or to effect any improvement of real importance in methods of distribution or manufacture, they still hanker after an extension of the communal management of public utilities and the like. A characteristic product of the times is a little book entitled "*Is Trade Unionism Sound?*" published by Messrs. Benn Brothers, at 2*s.* 6*d.* The author is Mr. J. H. Bunting, and forewords are contributed by Sir Peter Rylands and Mr. J. R. Clynes, M.P. The author's main theme is the necessity for greater production per head, and he points out very clearly that this is essential to an enhancement of the standard of living. He refuses, moreover, to credit Trade Unionism with any important share in the improvement in this standard effected here during the past century, and observes that in certain cases, at any rate, the result of trade union policy has been artificially to enhance the standard of limited classes at the expense of the commonalty at large. He advocates greater freedom of trade in labour. The weak point of the book lies in its statistical matter, where the author adopts the absurd figures as to the relative shares taken by capital and labour which have been put forward by the Fabian Society. There is the less excuse for this in that the census of production of 1906 gave authentic figures. Most interesting and reliable data on this head are also to be found in the paper by Felix Deutsch, published at Berlin in 1919 by Carl

TYRE ROUGHING MILL AT PARKHEAD FORGE.

CONSTRUCTED BY MESSRS. DUNCAN STEWART AND CO., LIMITED, ENGINEERS, GLASGOW.

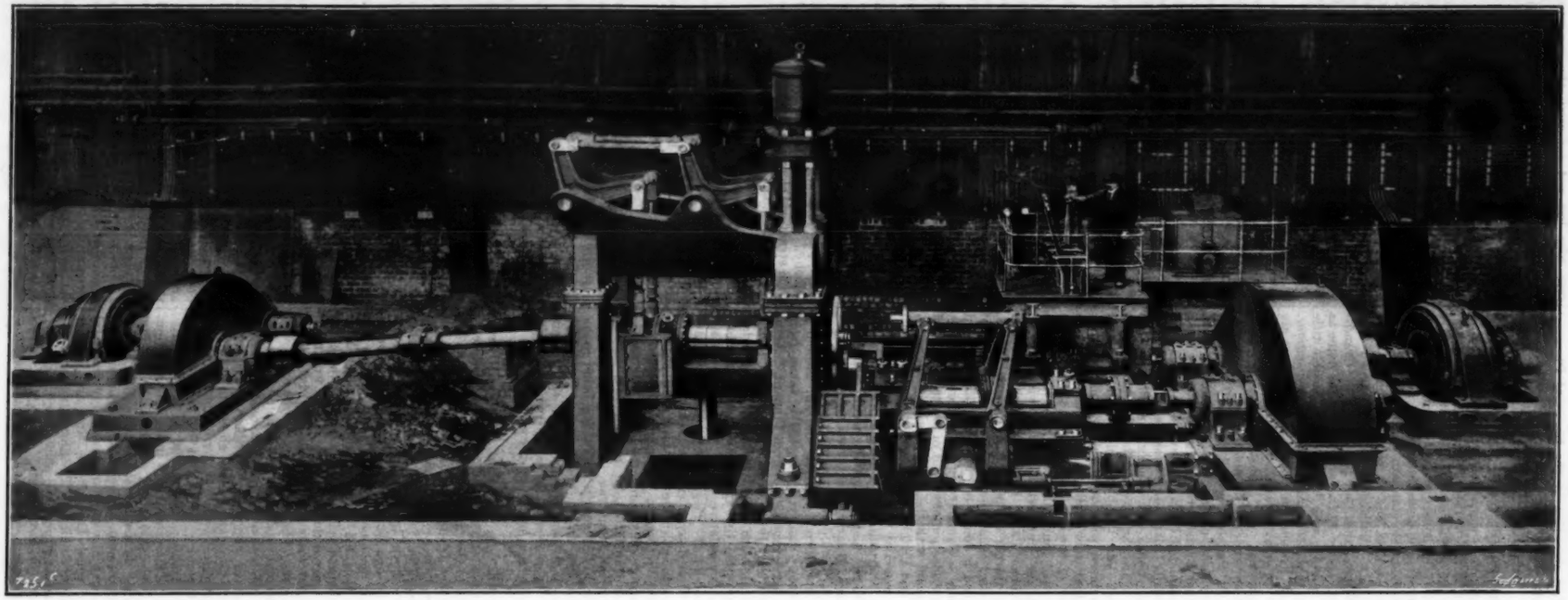


FIG. 1.

Heymans. Taking the 66 most prosperous manufacturing concerns in Germany, which for ten years had paid an average dividend of 10 per cent. and had an aggregate capital at pre-war values of 125,000,000*l.* Mr. Deutsch gave authoritative figures covering a decade, from which it appears that capital received about one-seventh as much as labour. Ordinarily the return on manufacturing capital is less than 6 per cent., in which case capital would receive only one-eleventh to one-twelfth as much as labour. The census of production showed that in this country the investment per head from 150*l.* to 200*l.* was in the case of manufacturing industries. Of course, on railways, where the investment at pre-war prices was of the order of 2,000*l.* per man employed, capital naturally received a larger return per head, and the same no doubt would be true in the case of shipping. Mr. Bunting also follows a blind leader in Mr. J. A. Hobson, who attributes the fall in real wages during the early years of the present century to the Boer War, neglecting entirely the important fact that it was during this period that the "ca' canny" policy was in special favour. The fact is that the men received less real wages in the main because they refused to earn more. As an American investigator of the conditions here at that time observed, "money had ceased to pull," a conclusion which was confirmed by Lord Leverhulme's experiences in connection with the cost of house building at Port Sunlight. In fact, materialism will not work any better in economics than it will in philosophy. Mind is the main factor in creating or in preventing the creation of wealth, and any would-be economist who neglects it should be granted Dogberry's plea in "Much ado about nothing."

Short illustrated handbooks on engineering drawing are not a novelty, but not many competent men have troubled to collate their views on the subject in book form. In Germany, Professor Riedler compiled the first of these books twenty-five years ago, and his practice and suggestions have formed the basis for the standard rules of German Industrials and for subsequent publications. The most recent of these publications, "*Das Maschinenzeichnen des Konstrukteurs*," by C. Volk [Berlin: Julius Springer, price 60 marks], is written for the designer rather than for the draughtsman. A good many of the 214 illustrations of the octavo volume of 73 pages, therefore indicate incorrect or practically inadvisable, uneconomical design in contrast to correct and recommendable safe design. Other pages and diagrams merely concern conventional practice, which is not always much more settled than the correct design. It is customary, *e.g.*, though not logical, to leave bolts unshaded in sectional diagrams, and to use the same thick shade lines in plan as in elevation. We are not certain whether the symbol for the diameter of a circle should be a circle crossed by a straight oblique line or crossed by a line of the shape of the integration symbol. The use of one Δ and of two $\Delta\,\Delta$ to indicate the fine and very fine finish of surfaces is new to us. Such usages are not international. But we can quite understand that the volume of Director Volk, who is director of the Beuth School in Berlin, will be much appreciated by young German engineers, and may be suggestive to others.

TYRE ROUGHING MILL.

MESSRS. DUNCAN STEWART AND CO., LIMITED, Glasgow, have recently built for Messrs. William Beardmore and Co., Limited, a powerful tyre-roughing mill, which we illustrate in elevation, plan and end view, on the two following pages, and perspectively above, this latter from a photograph taken in Messrs. Beardmore's Parkhead Works. The mill is capable of rough-rolling from slabbed blanks, ready for the finishing mill, locomotive tyres of the largest diameter; it can also produce broad rings up to 12 in. in width.

The outstanding feature of the mill is that the top roll spindle is made to rise and fall, an entirely new and patented arrangement which has strong advantages as compared with the type of mill having the bottom roll movable. It allows the bottom roll to be fitted so that none of its working parts are below the floor level, being thus free from scale. The power cylinder and parallel motion gear for the top roll spindle are placed on top of the mill housings, enabling quick inspection, easy adjustment and insuring freedom from scale; the guides for the top roll spindle cradle are also above the floor level. The third advantage is that the whole of the bedplate of the mill is continuous, which, besides rendering the mill stronger, insures the keeping in line of the roll spindles with each other. A further and very important advantage is that both the top and the bottom rolls can be changed in a few minutes without dismantling any part of the mill for the purpose. To facilitate the rolling of broad rings up to 12 in. in width, the bottom roll spindle is carried in a cradle which can be moved along the mill bedplate by means of a screw.

The roll spindles are driven separately from variable speed motors on the Ward-Leonard control system, supplied by the Metropolitan-Vickers Company, Limited, giving speeds from creeping-up to maximum. This renders the mill as powerful as an ordinary section mill, allowing large draughts and heavy output. The capacity of the roughing mill is such that it can feed two, or even three, finishing mills under continuous

TYRE ROUGHING MILL AT PARKHEAD FORGE.

FIG. 2.

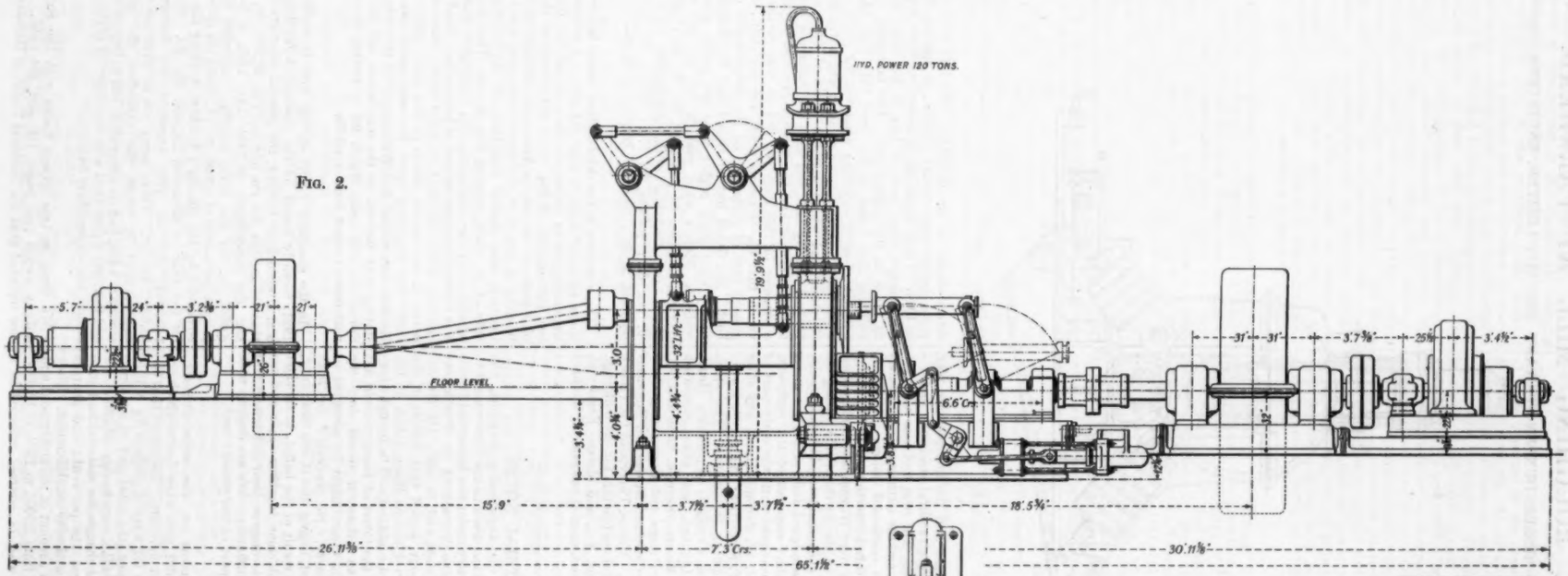
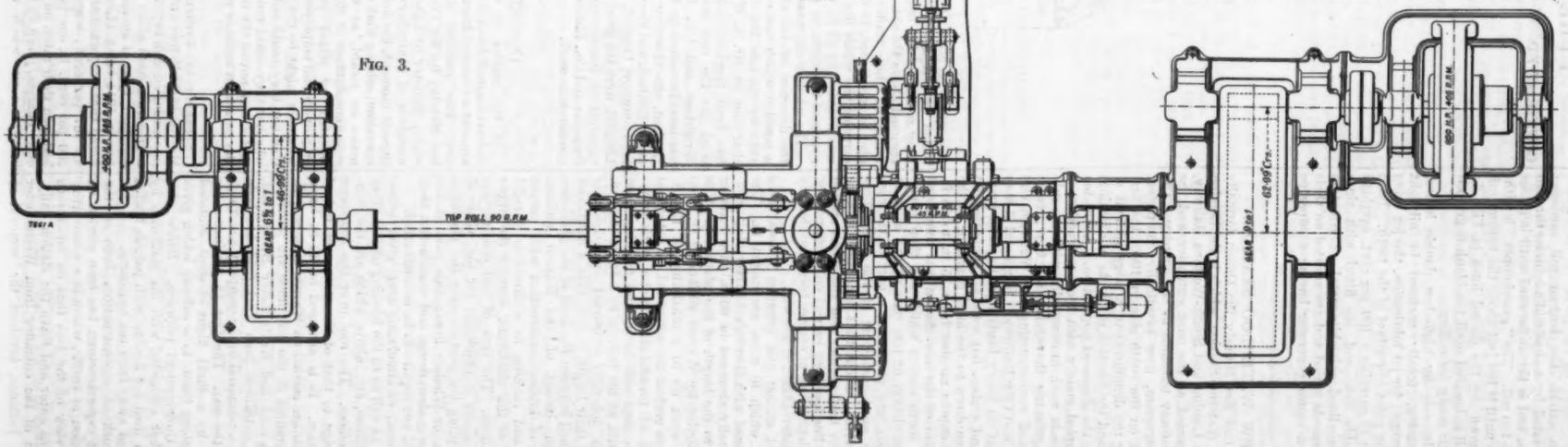


FIG. 3.



operation. The top roll is driven by a 400-h.p. motor giving a roll spindle speed up to 90 r.p.m., the bottom roll being connected to a 600 h.p. motor for a maximum roll spindle speed of 45 revolutions. The rolls are of the simplest design, consisting of short lengths, coned at the front end to prevent movement and consequent wear on the spindles; they are inserted in the ends of the main spindles and are held in place by cotters, a method of fixing which accelerates roll-changing. The supporting discs at the end of the roll spindles are of large diameter, and as these are bearing faces they are made separate and are bolted to the spindles; they are thus easily renewable.

The main housings are of cast-iron; the windows for the bearings of the top roll spindle carriage are fitted with cast steel wearing pieces. The bearings for both roll spindles are of the four-part type, lending themselves to easy adjustment, a necessary condition for economical running. The heavy end thrust on the machine is taken up by antifriction thrust bearings arranged to compensate automatically for wear, thus preventing undue loadings. The side guide rolls for steadying the tyre during rolling are carried in square guide boxes on the front of the main housing. They are coupled together by a link motion controlled from an hydraulic cylinder, and the motions can be adjusted at any time should there be unequal wear in the parts; the boxes are fitted with renewable and adjustable

strips having large areas. The slabbed blank having a central hole is placed on the pintle of the "grasshopper" shown astride the bottom roll carriage; this gear is operated by an hydraulic cylinder through levers and links, and is thrust forward until it places the blank on the top roll. The "grasshopper" is withdrawn and falls until it lies just above the bottom roll carriage, as shown by the dotted lines in Fig. 2; then the top roll is lowered until the blank is gripped between the rolls ready for rolling.

The motor drive is by high-class double helical machine-cut gearing, totally enclosed in oil-tight casings, and arranged for jet lubrication, the jet being thrown on to the point of contact of the teeth. Both sets are capable of carrying a 100 per cent. overload for a considerable time and are fitted with ring-lubricated bearings lined with white metal. The motors can have their speeds varied and are assisted on their peak loads by a motor generator having a capacity of 720 kw.

THE NEW WATERLOO STATION.

On Tuesday last Her Majesty the Queen formally opened the new Waterloo Station, which is the London terminus of the London and South-Western Railway, and is now regarded as the most extensive and the best arranged railway terminus in the country. The work of reconstruction, now practically completed, was commenced on the south side in 1900, the first stages including the demolition of a large amount of house property and the erection of blocks of dwellings to accommodate the displaced population. About ten years were occupied mainly with the construction of new approach roads, work in connection with the substructure, strengthening the arches for the present superstructure and reconstructing the Waterloo end of the Waterloo and City Railway. In general it may be remarked that no heavy loads were imposed upon existing piers and arches, but were all supported on foundations taken down to the hard gravel or to the London clay at depths ranging from 15 ft. to 25 ft.

The first section of the new station was completed outside the old south station which was then reconstructed, the completion of this part of the work in 1912 rendering six new platforms, a part of the concourse, and the south-east wing of the new offices available for service. From that time the work on the central (main line) station and the north station for the Windsor line has been carried on continuously, though its completion has, of course, been considerably delayed by the intervention of the war.

The completed station now occupies a total area of 24¼ acres, of which 10 acres are roofed in. The main roof is glazed with Rendle's "Invincible" glazing and is generally arranged in 60-ft. bays running at right angles to the length of the platforms. The principals are carried by Warren girders 12 ft. deep and varying in span up to a maximum of 130 ft. The ends of these girders are supported on octagonal columns formed of pressed-steel plates with ornamental cast-iron caps and bases, and tapering from 2 ft. 6 in. in width at the bottom to 2 ft. at the top. The columns are generally supported on brick pier foundations and their length is such that a headroom of 34 ft. is obtained between the level of the platforms and the bottom booms of the Warren girders. Bracing girders of lattice construction with curved bottom booms and running in a direction parallel with the length of the platforms, connect the upper ends of the columns. The type of roof construction briefly outlined above is employed for the whole of the station excepting the portion over the platforms of the northern or Windsor lines; this part of the roof being of more modern design and construction than the remainder did not require to be reconstructed.

A wide concourse, or circulating area, gives access to the platforms as well as to the booking offices, cloak rooms, waiting rooms, etc., above which are the company's general offices. The roof over the concourse is of similar design to that of the main roof, but of lighter construction. It is arranged in 30 ft. bays, and the principals are carried on Warren girders 7 ft. 6 in. deep. Entrances to the concourse are provided both from York-road and Westminster Bridge-road, and one of the entrances from York-road has been designed to form a memorial to the company's servants who fell during the war. The first 15 platforms are each connected by a short flight of steps, situated about half-way along them, to a subway which gives access to the Underground railways. Below this subway is another connected with the platforms by electric lifts and used for dealing with parcels traffic, which is thus kept away from the concourse.

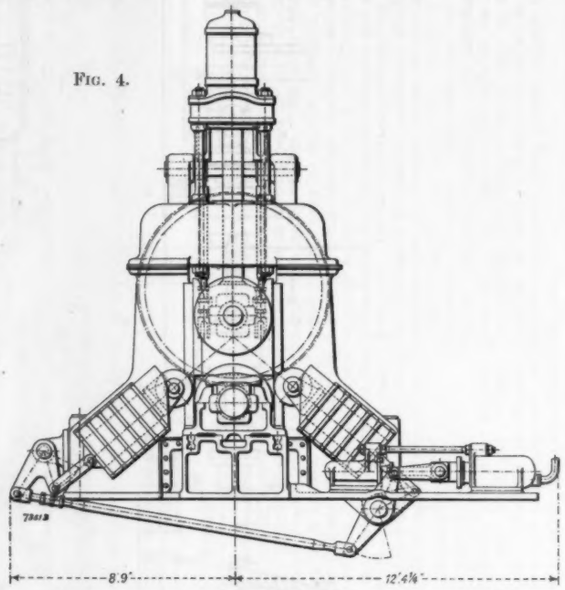
The whole work of reconstruction, both of the substructure and superstructure, has been carried on without interruption of traffic, which is a noteworthy achievement in view of the fact that on an average about 1,200 trains enter and leave the station daily. The construction of the entrance from Westminster Bridge-road, for instance, involved the removal of two spans of brick arches and the intermediate pier, which were replaced by structural steelwork under a busy section of the line. The new roof was also constructed above the old, and the latter was subsequently removed while traffic continued below. It should also be mentioned, in this connection, that the bridge carrying the whole line over Westminster Bridge-road was widened by 45 ft. on the northern side during the course of the work, to accommodate additional tracks.

The whole work was designed and carried out under the direction of the chief engineer of the company, a position which was occupied until the early part of 1914 by the late Mr. J. W. Jacomb Hood, and since that time by Mr. A. W. Szlumper; Mr. R. D. Hawes has been resident engineer throughout. The steelwork for the roof was supplied by Messrs. Head, Wrightson and Co., Limited, and other steelwork has been furnished by Messrs. Dorman, Long and Co., Limited, the Horseley Bridge and Engineering Company, Limited, and the Cleveland Bridge and Engineering Company, Limited. Messrs. Perry and Co. (Bow), Limited, were the general contractors for the buildings, excavations, foundations, &c., and Messrs. Eastwood, Swingler and Co., Limited, carried out some of the road construction work.

TYRE ROUGHING MILL AT PARKHEAD.

CONSTRUCTED BY MESSRS. DUNCAN STEWART AND CO., LIMITED, ENGINEERS, GLASGOW

FIG. 4.



INDUSTRIAL NOTES.

In the matter of the engineering lock-out, the Labour Council decided last week to ask Government to appoint a Court of Inquiry under the Industrial Courts Act. The question was introduced in Parliament last Monday by Mr. Clynes, and, in reply, Dr. Macnamara, Minister of Labour, stated that ballots of the members of a number of unions being taken at the present moment, the Act could not well be brought into operation, adding that the Court of Inquiry could not make an award, as an arbitrator would do; the recommendations of the Court might be accepted or rejected by either party. He appealed to both employers and employed, urging that it was their duty, whatever might be the result of the ballot, to consider whether they could not come together again and see whether they could not compose their differences and find a way out of the difficulty. We are dealing with the debate in another part of our present issue.

Speaking in Parliament on the same occasion, Mr. Gould, M.P. for Cardiff, gave a few figures which are interesting enough to put on record. He stated that the engineering costs alone for a set of engines for a 1914 standard type of steamer (the total cost of construction in 1914 being 11,447*l.*), were to-day 29,260*l.* He found that proportional charges for material had gone up 167 per cent., wages 118 per cent., and charges 200 per cent. in one particular establishment. They had seen their rates, on account of unemployment and other charges, jump up from 2,100*l.* in 1914, to 12,600*l.* in 1922, a rise which was, of course, reflected in a direct charge on the industry. The hull costs of the same steamer were to-day 70,000*l.*, as against 34,655*l.* in 1914. There, again, the increases in labour, material and charges were, more or less, in the same relation as those in the engine cost. The increased cost of building that vessel to-day over 1914 was 53,150*l.*, without allowing anything whatever for profit. Last week he (Mr. Gould) sold a steamer which was built in Germany and which would be finished next month, for just exactly 148*l.* less than the difference between the pre-war cost and the present-day cost of building a steamer in this country, and he was prepared to vouch that the Germans made 100 per cent., at the present rate of exchange, on the construction of the boat. Mr. Gould further stated that the wages paid to-day were much higher than the public generally realised. Platers were paid 7*l.* 9*s.* 6*d.* per week; riveters, 5*l.* 18*s.* 6*d.*; smiths, 6*l.* 7*s.* 6*d.*; drillers, 5*l.* 3*s.* 6*d.* On time work, shipwrights were paid 3*l.* 14*s.* 6*d.*; joiners, 3*l.* 17*s.*; fitters, 3*l.* 12*s.* 6*d.*; painters, 3*l.* 8*s.*; painters' helpers, 3*l.* 5*s.* 6*d.*

The situation in the shipbuilding trades has become worse since our note on page 334 *ante*. A proposal by the employers to divide the first cut of 16*s.* 6*d.* into two instalments, of 10*s.* to be withdrawn at the end of March and 6*s.* 6*d.* in April—the withdrawal of the balance of 10*s.* to be discussed later—was rejected by the men, who claimed that there should be only two cuts of 5*s.* each, making 10*s.* in all. This was not agreed to by the employers, and a complete deadlock was reached towards the end of last week. The Parliamentary debate to which we refer briefly above and in detail in our special article in this same issue covers both the engineers' and the shipyards situation. Notices were posted last Wednesday in the shipyards stating that 10*s.* 6*d.* of the war bonus will be withdrawn on and from March 29, a further 6*s.* being withdrawn on and from April 26.

In the quarterly report ending with December 31, 1921, recently issued by the Associated Blacksmiths' and Ironworkers' Society, the general secretary states that the income for the quarter was 42,187*l.* 9*s.* 2½*d.*, and the expenditure 50,283*l.* 11*s.* 2½*d.*, a loss of 8,096*l.* 2*s.* for the three months. Included in the income was a sum of 2,598*l.* 1*s.* 7*d.*, being the overdraft advanced by the society's bankers, making the total for the year so advanced 25,345*l.* 19*s.* 3*d.* The expenditure for the year exceeded the income by 53,997*l.* 19*s.* 2*d.* There being yet no evidence of an improvement in trade, the executive, the general secretary adds, had no alternative but to impose a levy and institute a loan fund with the object of making the income and expenditure balance.

We dealt in two former issues with the Scottish railway award (see pages 116 and 164 *ante*). It is now reported that the National Union of Railwaymen

have decided to accept the proposal as applicable to the English and Welsh railways.

A resolution was passed at a meeting of railwaymen held on Sunday last at Manchester, (1) pledging resistance to any interference with the principle of the eight-hour day, or the standard basic rates of wages, protesting against the introduction of casual labour on the railways, and calling upon the Executive Council of the National Union of Railwaymen to take immediate steps to deal with this question; (2) welcoming the introduction of local departmental committees and railway councils, and trusting that they will lead to the smooth working of the railways; (3) expressing the belief that the position of the workers is seriously jeopardised by the existence of too many unions, and welcoming the recent action of the union in opening up negotiations with all societies catering for transport workers with a view to fusion; (4) expressing the belief that only by a reversal of the Government's policy and a return to trading with all nations can the normal conditions of trade be restored.

A provisional settlement in regard to hours and wages in the building trades has been arrived at following a recent meeting of the National Wages and Conditions Council. The representatives have agreed to a wage reduction of 2*d.* per hour on April 1, whilst a further reduction of 2*d.* per hour from June 1 is to be submitted to a ballot, and working hours for the months of December and January are to be reduced to 41½ per week, the alteration in summer hours being deferred until January next. In the event of failure of agreement on the question of the working week at the meeting next January, the employers' present position is not to be prejudiced. The men are to have an opportunity of confirming the second reduction. In the event of failure to agree on the second reduction the present position of the employers is to remain unprejudiced. In the application of the second reduction special consideration is to be given by the Council to the mitigation of the results of the reduction upon wages in the lower paid districts.

The Ministry of Labour state that employment continued bad during February, but showed a slight improvement as compared with January. The industries in which the improvement was most noticeable were coal-mining, pig-iron manufacture, iron and steel manufacture, the woollen and the worsted industry, and the pottery trade. The percentage unemployed among members of trade unions from which returns are received was 16·3 at the end of February, compared with 16·8 at the end of January. The percentage unemployed among workpeople insured under the Unemployment Insurance Act was 15·7 on February 21, as compared with 16·2 at the end of January. The percentages for males and females on February 21 were 17·6 and 10·8 respectively. The total number of workpeople registered at the Employment Exchanges as unemployed on February 28 was approximately 1,837,000, of whom 1,411,000 were men and 318,000 were women, the remainder being boys and girls. On January 31 the number on the live register was 1,906,000, of whom 1,458,000 were men and 333,000 were women. In addition to those unemployed, 156,000 males and 110,000 females were registered on February 21 as working systematic short time in such a manner as to entitle them to benefit under the Unemployment Insurance Act. On January 31 the corresponding figures were 166,000 males and 122,000 females. The number of vacancies notified by employers to Exchanges and unfilled on February 28 was 18,000, of which 4,400 were for men and 11,700 for women, compared with 20,100 on January 31.

The changes in rates of wages reported as having taken effect in February, in the industries covered by the statistics, resulted in a net reduction of over 390,000*l.* in the weekly full-time wages of over 2,400,000 workpeople. The wages of building trade operatives, except painters and decorators in Scotland and plumbers in some districts, were reduced by ½*d.* per hour in nearly all the important centres. Nearly 800,000 coal miners sustained reductions ranging in different districts from under 2 per cent. to over 8 per cent. on current rates. In shipbuilding the principal classes of piece-workers sustained further reductions by the withdrawal of a third instalment of the advances granted during the war under the "Standard Ship Cycle" awards. Steel smelters had their wages reduced by 33⅓ per cent. on standard rates, and there was a reduction of 20 per cent. on standard rates in the case of iron puddlers and millmen in the Midlands. The wages of tramway employees generally were reduced by 3*s.* and 1*s.* 6*d.* per week in the case of workers 18 years of age and over and those under 18 respectively. Other important reductions during February affected pottery workers, paper makers, coach builders, tin-plate makers in the Midlands, and furniture trade operatives in London and various provincial towns. There were also reductions in the minimum rates fixed under the Trade Boards Acts for workpeople employed in the jute and other trades.

The number of trade disputes involving stoppages of work, reported to the department as beginning in February, was 66. In addition, 49 disputes, which began before February, were still in progress at the beginning of the month. The principal dispute was that involving about 4,000 wagon builders and repairers, arising out of a proposed reduction in wages.

The total number of workpeople involved in all these disputes (including those workpeople thrown out of work at the establishments where the disputes occurred, though not themselves parties to the disputes) was about 33,000, as compared with 18,500 in the previous month, and 44,000 in February, 1921. The estimated aggregate duration of all disputes during February was about 316,000 working days, as compared with 184,000 days in January, 1922, and 758,000 days in February, 1921.

On March 1 the average level of retail prices of all the commodities taken into account in the statistics, prepared by the Ministry of Labour (including food, rent, clothing, fuel, light and miscellaneous items) was about 86 per cent. above that of July, 1914. The corresponding figure for February 1 was 88 per cent., and that for March 1, 1921, 141 per cent. The highest point reached by the figure was 176 per cent. above the pre-war level, in November, 1920. Apart from a slight interruption in the summer of 1921, there has been a continuous decline since that date, and the figure now recorded is lower than that for any date since December, 1917.

SOCIETY OF GLASS TECHNOLOGY.

A MEETING of the Society of Glass Technology was held in Stourbridge on March 15. During the forenoon members had an opportunity, through the courtesy of the respective directors, of visiting the works of Messrs. King Brothers (Stourbridge), Limited, and of Messrs. E. J. and J. Pearson, Limited, both firms being engaged in the manufacture of refractory materials. After lunching together at the Talbot Hotel, Stourbridge, members proceeded to St. Thomas' Hall, where the general meeting was held, when the president, Dr. M. W. Travers, F.R.S., occupied the chair.

The first paper presented was entitled "*Some Notes on the Production of Colourless Glass in Tank Furnaces*," by A. Cousen, B.Sc., A.R.C.S., and Professor W. K. S. Turner, D.Sc. In presenting the paper, Professor Turner said that the use of selenium as a decolouriser, generally in the elementary form, and accompanied by cobalt oxide and arsenious oxide, was now common. The conditions governing its successful use were not clear, particularly where saltcake was one of the batch constituents. In order to throw light on these points, Mr. Cousen had made a series of melts starting with the normal bottle glass batch: Sand 1,000 parts, limespar 200, soda ash 370, for which ¼ oz. of selenium and 1/8 oz. of cobalt oxide per 1,000 lb. of sand were sufficient to decolourise (no arsenic being used) when the melting was at 1,375 deg. and occupied 3½ hours. Where 10 parts of soda ash were substituted by an equivalent weight of saltcake, twice as much selenium was needed, and even four times the amount did not prove excessive. With 20 and 40 parts of soda ash replaced by saltcake, 2 oz. of selenium per 1,000 lb. of sand gave good decolorisation. The effect was partly due to the solution of iron compounds from the pot by saltcake and partly to the direct reaction between saltcake and selenium. This latter action had been observed qualitatively when selenium was brought into contact with molten saltcake in a neutral atmosphere, some sodium selenite being produced. The amount of iron oxide in the glass which could be successfully decolorised was found to be not more than about 0·11 per cent. Fe_2O_3. By the introduction of selenium as sodium selenite, much less of the element was required in the case of the soda ash batch, since the tendency to burn out was checked, selenite equivalent to only ¼ oz. per 1,000 lb. of sand being in excess. With saltcake present in the batch the advantage was not so well marked, since the colouring effect of the selenium was again affected by the saltcake.

A discussion followed in which there took part the President, Messrs. E. A. Coad-Pryor, W. P. Johnson, and W. J. Rees. Mr. Cousen and Professor Turner replied.

Mr. W. J. Rees, B.Sc.Tech., F.I.C., followed with a paper entitled "*Review of the Preliminary Specification for Refractory Materials used in the Glass Industry.*" This paper referred mainly to the "Provisional Specification for Glass Refractories" issued by the Society of Glass Technology and published in its Journal for May, 1919. Mr. Rees observed that little use had been made of the "Specifications" up to the present and inquired why this was so, whether they were adequate, and if not, in what directions they could be amended. He emphasised the point that the "suggestions" mentioned were included as such, and not as part of the provisional specification. These were bound, in the first place, to be tentative, pending the collection of further data which would enable standard specifications to be prepared which would be acceptable to both the makers of refractories and glass manufacturers. The specifications given for silica bricks and cement were satisfactory, as bricks which met it had given good results in practice. He suggested, however, that it might be desirable to insert clauses as to the maximum true specific gravity, and the minimum mechanical strength. It had been suggested by the American Ceramic Society that the effective modulus of rupture of a standard 9-in. brick, set on knife edges (6 in. span) should not be less than 500 lb. per square inch. Silica bricks should be stored in a dry place.

Considering next the question of tank blocks, Mr. Rees remarked that the poor quality of these seemed to be giving great trouble to glass manufacturers, and he inquired whether the failure was invariably due to the blocks being of unsatisfactory quality. The explanation might possibly be found in the fact that many different types of glass were now being produced, and that probably modern temperatures were higher than formerly. In some cases blocks were spoilt by improper treatment. There was an unexplored field in the questions arising from the precise behaviour of glass batches with blocks. Unbalanced glass batches were very possibly a cause of block failure. When tank blocks were used for the first time it was desirable that the furnace be raised to a high temperature before any glass batch was filled on. Coatings on blocks had been tried, but none was really successful. Two most important factors connected with tank blocks were porosity and uniformity of texture. Eight photographs were exhibited showing the interior faces of 6-in. cubes cut from the corners of blocks. Of these only two were satisfactory, the one having a porosity of 21 per cent. and the other of 20 per cent. It was also desirable that the grog should have the same composition as the rest of the blocks or have the same approximate solubility factor. More information was needed as to the solubility of clays in glass.

For the testing of tank blocks there were several methods, but not one gave results that would recommend its universal adoption. Three methods were mentioned: (1) Holes were drilled in the block, and these were then filled with batch. This method was defective because the skin of the block was disturbed. (2) Crucibles were cemented on to the top of the block, and then filled with batch. (3) The blocks were immersed in the molten glass.

After referring to the trouble experienced with the spouts and needles of automatic machinery, Mr. Rees went on to examine the use of raw pot clays and grog. This was a matter of considerable difficulty, as the conditions were very variable, in respect both of temperature and of type of glass being made. The question which demanded more consideration was the behaviour of siliceous as compared with aluminous clay. Siliceous pots seemed to be inferior as regards mechanical strength. Various clauses of the provisional specification were then considered in detail. It was suggested that notice should be taken of the effect of the interaction at high temperatures of the various clays and grog in the pot mix. Mr. Rees also suggested the insertion of a provision as to the contraction of the pot mix from the wet state to that fired at, say, cone 14 (1,410 deg. C.).

An instructive discussion followed in which there took part the President, Colonel C. W. Thomas, Professor W. E. S. Turner, E. A. Coad-Pryor, and G. V. Evers. Mr. Rees replied.

The president intimated that the next meeting of the society would be the annual general meeting and would be held at Sheffield on Wednesday, April 5. It would be followed in the evening by the annual dinner to be held in the Royal Victoria Station Hotel, Sheffield.

SIXTH SWISS INDUSTRIES FAIR, BASLE.—Traders and importers are cordially invited to visit the Sixth Swiss Industries Fair, which will be held in Basle from April 22 to May 2. It will afford them a unique opportunity of obtaining a clear and comprehensive idea of the scope of Swiss manufacturers and of becoming better acquainted with genuine Swiss goods of every description. Further data can be obtained from the Swiss Legation, Commercial Department, 32, Queen Anne-street, W. 1.

CONFERENCE AND CONGRESS OF CHEMISTRY, FRANCE.—The International Union of Pure and Applied Chemistry, 49, Rue des Mathurins, Paris, 8, have issued the programme of the third international chemistry conference, which is to take place in Lyons, from June 27 to July 2. A number of meetings and visits to works are to take place. The last excursion on the programme will bring the visitors in proximity to Marseilles, in which town there is to be held, from July 2 to 7, the second congress of industrial chemistry, where further meetings and visits to works are to take place. Information on both functions can be obtained from the Union Internationale de la Chimie Pure et Appliquée, at the above address in Paris.

SULPHUR.—The intensity of the sulphur crisis is greater than ever; the production of American sulphur still increases; in 1911 it was only 205,000 tons, in 1920 it reached 1,255,000 tons. American sulphur has completely conquered the French, Swedish and British markets, and is threatening to drive Sicilian sulphur out of the German, Spanish and Portuguese markets, says *The Anglo-Italian Review*. In face of this competition the output of Sicilian sulphur has shrunk from 574,000 tons in 1911 to 223,000 tons in 1920. The trouble lies in the great difference in the cost of production; in America it is about half what it is in Italy, therefore owners, mine contractors and labour are now all agreed to submit to great sacrifices so as to reduce costs, and the Italian Government have decided to reduce taxation and railway rates. Concessions are also demanded in regard to Customs entry duties on all materials, and machinery required to work the sulphur mines. It is reported that a representative of the American producers has come lately to Italy to discuss an agreement to control and limit competition.

THE MARQUIS BLOWPIPE SOLDERING IRON.

IN the accompanying illustration is represented a handy combination appliance being introduced by Messrs. Buck and Hickman, Limited, of 2 and 4, Whitechapel-road, London, E. 1. This is known as the Marquis blowpipe and soldering iron, and from our illustration its uses will be readily understood. Below is shown the blowpipe, to the rear end of which is attached an ordinary rubber tube to a gas supply pipe. The other end of the blowpipe is fitted with a burner with the holes necessary for the required air supply.

The jet and nozzle form a miniature Bunsen burner, and produce a regular blowpipe flame of excellent heating characteristics. The soldering bit is pivoted in a fork of bent steel notched out at the back end so as to slip over the nozzle of the burner, where it is held by a hexagonal nut of a size just sufficient for the parallel sides to pass and lock between the arms of the fork. The bit can be set to any angle and is heated by the burner flame playing upon it. It can be very quickly applied or removed from the burner; for the latter operation a series of jerks suffices, and it is unnecessary to touch the hot bit, so that the operator can quickly change from one application to the other as work may require. It may be mentioned that the body of the blowpipe is enlarged to form a good grip, and is partly surrounded by non-conducting material so that it is not uncomfortable to hold in the hand.

GRAVITY-TYPE TIPPING GEAR FOR MOTOR WAGONS.

IN the earlier developments of the motor wagon comparatively little attention was paid to questions of loading and unloading, but of recent years the bearing of these on overall transport charges has come to be generally realised, and the subject has been given much attention. For many types of load a tipping body gives an unloading arrangement which could not well be improved on, and tipping systems have been introduced by practically all motor wagon builders. These are variously arranged to be operated by hand, by mechanical or hydraulic gear from the engine, or by special engine. Many have particular advantages of their own, but in some cases we think an insufficiently steep tipping angle has been arranged for, so that with sticky loads, such as damp sand or manure, there has been difficulty in clearing the whole of the load out of the body without resorting to spade work.

In the arrangement of a tipping gear the simplest procedure would appear to be to fix rollers so that the body could be run along them to the end of the chassis

TIPPING GEAR FOR MOTOR WAGONS.

CONSTRUCTED BY THE LACRE MOTOR CAR COMPANY, LIMITED, LONDON.

Fig. 1.

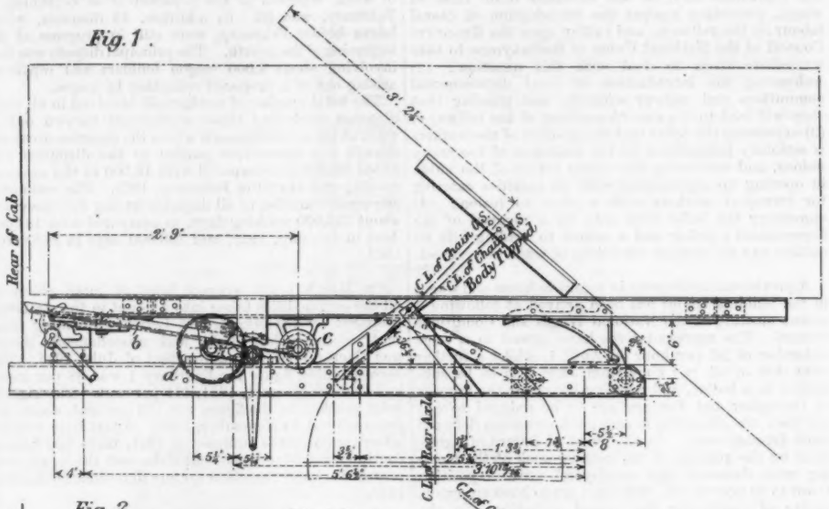


Fig. 2.

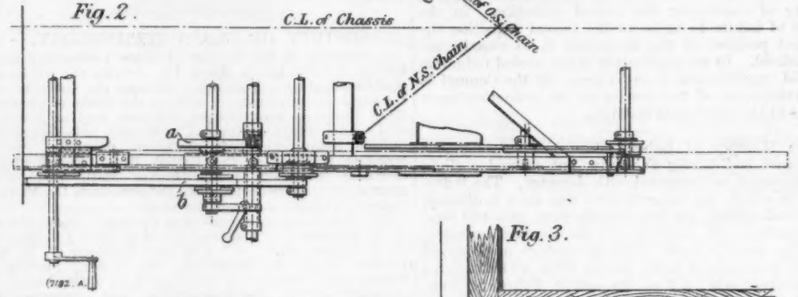
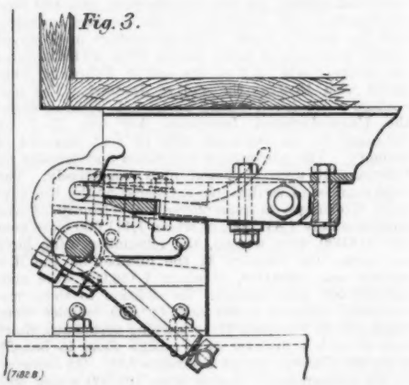


Fig. 3.



and allowed to tip over naturally at the end. Some control would, of course, be necessary, but it is needless to enter into details here, since with the ordinary length of body and height of chassis it will be found that this simple arrangement gives a tipping angle of only about 30 deg., which is hardly sufficient for the sticky loads already referred to. Steeper angles may be obtained with the ordinary screw gear, and many excellent arrangements of this kind are on the market, both for hand and power operation. An inherent disadvantage of this method of tipping lies, however, in the fact that the load has actually to be lifted during part of the movement, and although there is no difficulty in arranging the gear to allow of this, the necessity naturally increases the gear ratio and consequently increases the time required for tipping. Even with the ordinary types of gear in which the body moves backwards on rollers and then tips, it will be found that the centre of gravity of the load rises during tipping, so that again the load has to be lifted. These considerations add interest to the new gravity-type tipping gear which has been introduced by the Lacre Motor Car Company, Limited, of 78, York-road, King's Cross, N. 1, and Letchworth, Herts. With this gear the centre of gravity of the load during the tipping operation moves along a straight line, with a slight downward slope towards the rear end of the wagon. The load is at no time lifted, and as a more rapid gear can consequently be used, very quick tipping is achieved. It is stated that a load can be tipped and the body recovered in under 30 seconds.

The gear is illustrated in Figs. 1 and 2 annexed. The driving members by which the body is moved consist of a pair of racks situated one on each side of and parallel with the side members of the chassis frame. One of the racks can be seen at *b* in both Figs. 1 and 2. These racks are pivoted at one end to a cross-shaft carried by brackets secured to the underside of the body frame, and this cross-shaft carries rollers *c* at its outer ends. The rollers run on ramps, one of which can be seen in Fig. 1. The ramps are secured to the chassis frame and it is clear that as the body is traversed backwards it will tip owing to the rollers travelling up the ramps. At the rear end of the chassis two rollers are fixed on the cross member, and ramps fixed to the underside of the body frame travel over them. The arrangement can clearly be seen at the right-hand side of Fig. 1.

The body is traversed by means of gearing shown at *a* in Figs. 1 and 2. There are two cross-shafts fitted to the chassis frame, one of which is operated by a handle crank. This shaft carries pinions which mesh with spur wheels carried by the other shaft, and further pinions secured to the spur wheels operate the racks. The gear ratio gives rapid tipping, as we have already pointed out. When the body is in position for travelling two lugs on the back ramps fit below brackets fixed to the chassis, while the front end of the body is held in position by a safety catch, which is detailed in Fig. 3. The catch is released by the handle attached to it, which can be seen in Fig. 2, and when the body returns to position after tipping the catch automatically comes into action. With the normal 2-ton chassis this gear gives a tipping angle of about 42 deg.

FOUNDRY BUILDING OF WOOD.—When the enlargement of the engineering works and foundry of Messrs. E. Lacis and Co., of Trier, was put in hand some time ago, structural iron was at so high a price that the firm decided to make a large use of wood in their new foundry. This is a building, 108 m. long and 40 m. wide, longitudinally divided into three bays, the central one of which rises to a height of over 13 m. (43 ft.). The roof of this bay rests on pillars of particularly well-seasoned timber. To minimise fire risks the concrete foundations of the pillars, which also carry the crane track, have been raised above the floor level, and the wooden pillars are sheathed with concrete slabs. Wood is also used in the roofing. So far, says *Stahl und Eisen*, no trouble has arisen from the use of wood, and the absence of vibrations even with heavy crane loads is commented upon.

AUTOMATIC SPIRAL COAL SEPARATOR.

FIG. 1.

FIG. 2.

THE elimination of shale, slate, &c., from coal after it has been raised is a necessity if the coal is to be commercially attractive, for the consumer not only objects to buy rock at the price of coal, and to pay freight upon it, but he also dislikes incombustible material being supplied to his furnaces. The re-establishment of effective competition between the coal mines has placed the consumer in a stronger position with regard to his demand for clean coal, and mine managers are therefore having to pay more attention to getting rid of shale before the coal is shipped. Hand picking is costly, and any automatic method of cleaning the coal is earnestly to be desired. The problem is not easy, for coals, as well as the shales with which they are associated vary so much in their hardness, weight and other physical characteristics by which they might be automatically distinguished. Nevertheless a simple automatic method of separation has been devised, and has come largely into use in the United States. It depends upon the fact that the friction of shale and rock sliding down an inclined plane is greater than that of coal, a result due probably both to the greater density of the shale and to its less graphitic nature.

The apparatus by which the separation is effected consists of a central column carrying a double or triple-threaded sheet iron spiral running from the top to the bottom. Another larger flanged spiral also surrounds the column in a similar fashion. The construction will be understood from Figs. 1 and 2, above, the first figure showing a plant standing by itself, and the other a pair of plants in working position. In the illustrations, the triple spiral type is represented. The raw coal is divided by a triple shoot into three separate streams, each of which is led on to the top of the corresponding spiral. The coal runs down the spiral with considerable velocity under the action of gravity. Pieces of pure coal attain sufficient speed to cause them to flow over the edges of the spiral shoots by centrifugal force. They then fall into the flanged shoot and are discharged into a hopper at the bottom. Shale and rock, owing to their greater friction, travel more slowly than coal, and never attain sufficient speed to cause them to leave the spirals. Hence such material is separated from the pure coal, and is delivered by the spirals into a special hopper.

Automatic separators of this kind were first devised for anthracite coal, and they proved so successful that their use has been extended to coal of all kinds. For effective separation it is necessary that the material treated should be of reasonably uniform size. Coal from 6 in. down to ¼ in. can be dealt with, this range being divided into five sizes each of which is treated separately. It is also necessary that each separator should be built, or set to suit the particular class of coal that a colliery is mining, as coals vary considerably in their frictional properties. Setting is effected by altering the removable friction plates provided at intervals upon the upper surface of the spirals, and adjustable spirals are also supplied which permit the angle of descent to be altered. The size of the apparatus will be gathered from the fact that the spiral illustrated in Fig. 1, has an extreme height from the top of the inlet shoot to the ground of 11 ft. 6 in. when designed for anthracite, or 13 ft. 2 in. when designed for bituminous nuts, the overall diameter being 57 in.

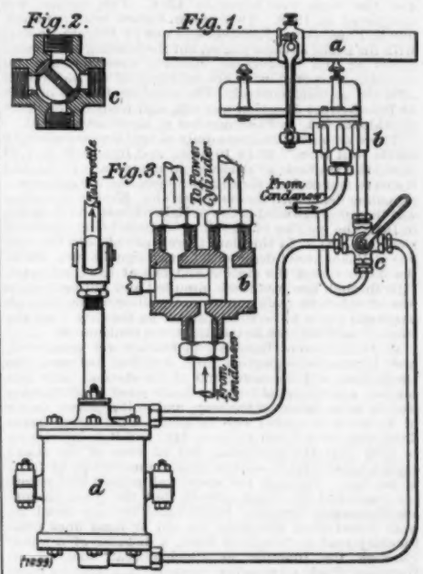
We understand that more than 3,000 of these automatic separators are at work in the United States. One plant alone, the Old Ben Coal Corporation, which is mining anthracite at West Frankfort, Illinois, has 60 of these separators, which handle easily 3,000 tons of coal in 8 hours. The plant is operated by one foreman and 10 men, not including two men loading coal. Of the staff mentioned, two men are easily able to attend to the spirals, the others taking care of the screens, conveyors, motors, &c. An official report from the company states that "the results are entirely satisfactory, and impurities are removed more thoroughly than by washing, without the drawbacks incidental to the latter process." A spiral separator has been at work in South Wales for some time at the Great Mountain Colliery, dealing with anthracite at the rate of 8 tons per hour, and the results have justified the company in placing an order for six more of the same type, so that the whole output of this colliery can be cleaned by the method in question.

The spiral separators are constructed by the Anthracite Separator Company, of Hazleton, Pa., U.S.A., who are represented in this country by Messrs. Hugh Wood and Co., Limited, of Sun Buildings, Newcastle-on-Tyne and 65, Fenchurch-street, London, E.C. 3.

AN ANTICIPATING MARINE GOVERNOR.

THE Ramsay marine governor, one form of which is shown in the annexed figures, has now been manufactured for many years and has come into use to a considerable extent. This governor, manufactured by The Ramsay Marine Engineering Company, Limited, of Basildon House, Moorgate-street, London, E.C. 2, is of the anticipating type, and acts on the throttle before racing begins and when the stern of the ship begins to rise and there is danger of the propeller leaving, or partly leaving, the water. Our figure shows the simplest form of the governor which is intended for use on coasters, trawlers, and similar comparatively small vessels. The essential feature of the arrangement is a closed horizontal tube which is shown at *a* in Fig. 1. This tube contains several pounds of mercury and is set fore and aft in the ship. It is carried in a pivoted bridle and can swing in a vertical plane within limits imposed by the two adjustable stops which can be seen below it in Fig. 1. Connected to the bridle there is an arm which operates a piston valve indicated at *b* in Fig. 1 and shown to a larger scale in Fig. 3. The apparatus is operated by the flow of the mercury in the tube as the tube is tilted by the motion of the vessel.

The governor may be set to suit the weather which the vessel is encountering. In a following sea the tube would be set inclining upwards towards its after end. In these circumstances as each wave passed and the stern fell there would be a tendency for the propeller to leave the water at the back side of each wave. The fall of the stern would, however, cause the mercury to flow in the tube, so that the balance would be upset and the tube would swing over towards the second stop. This would operate the piston valve. This valve controls the movement of the piston in the main operating cylinder *d* which can be seen at the left-hand side of Fig. 1. The piston of this cylinder is connected to and controls the throttle valve, the piston itself being operated by atmospheric pressure. Connections are made from the ends of this cylinder to the piston valve through a four-way cock *c* as shown in Fig. 1, a cross-section of the cock being given in Fig. 2. A third connection is made from the piston valve to the condenser and as may easily be traced from Fig. 1, the connections result in one end of the operating



cylinder being connected to the condenser and the other to the atmosphere. The moving-over of the piston valve by the rocking of the mercury tube changes over the connections, however, so that the operating cylinder piston moves and closes, or partly closes, the throttle valve. As the ship recovers an even keel the mercury tube swings back, the action is reversed and the throttle is opened again. The four-way cock is introduced so that the action of the governor may be set for a head-on sea instead of a following sea. The mercury tube may be adjusted to suit the trim of the ship, either by means of the stops or by sliding it endwise in its bridle.

In the case of ships of a larger class this governor in the simple form we have described is not altogether complete enough in its action. In the case of long waves in open seas the performance is entirely satisfactory, but when "short" following seas have to be dealt with there is some danger that the propeller may be exposed even when the boat is on an even keel. For such conditions an emergency feature is added to the governor. In this "combined" governor the anticipating feature operates in the manner we have already described, but the mechanical details are somewhat different. In place of the mercury, a polished steel ball is used which runs in a vee groove on the upper side of a pivoted lever. Inclination of the ship causes the ball to roll and tilt the lever which controls a ball valve and admits air to a relay which operates a piston valve of similar type to that shown in Fig. 1. The ball and lever are carried in a tube which may be set to suit the trim of the ship. The emergency feature which comes into operation in the case of any tendency to race in a short sea or in case of loss of a propeller or similar breakdown, consists of a reciprocating lever coupled up to the air pump lever or some other suitable moving part. The lever is a double one,

consisting of two arms spring-connected. One arm is driven as explained, the second obtains its motion from the first, and is weighted at its outer end. In the event of any tendency to race the inertia of this second lever carries it beyond its normal travel and it operates a valve which admits air to the anticipating governor relay, so that the throttle is acted on as in the case of operation of the anticipating feature. A catch is incorporated in connection with the piston valve so that in the event, for instance, of a shaft breakage, when the valve moves over, it is held over. This results in the throttle being held closed. This feature may be thrown out of action as desired, and would normally only be used if the engine were to be left unattended.

ALL-ELECTRIC AUTOMATIC POWER SIGNALLING ON THE METROPOLITAN RAILWAY.*

By WILLIAM WILLOX, M.A., M.Inst.C.E.

IN 1905 when electric trains commenced to run on the Metropolitan Railway, the system of signalling was mechanically controlled by Spagnoletti lock and block. The number of trains between Praed-street Junction and Aldgate—about 5 miles—was then 621 per day on both roads, and the number of signal sections was 49. The number of trains was increased, and it was found necessary to introduce automatic signalling controlled by track circuits. The system chosen was all-electric, and the work was begun in 1908. This section was completed in 1909. Two power frames were installed, one at Praed-street Junction and one at Aldgate, to deal with the traffic at these places, but the existing mechanical boxes at the intervening stations were retained for shunting purposes, with the addition of the safeguards afforded by track control. The number of trains in 1913 at Praed-street Junction was 863, and from Baker-street to Aldgate 983, and the number of signal sections 91.

There are about 20 hours daily of continuous passenger traffic, but from 7.30 to 10 a.m., and from 4.30 to 7.30 p.m., the traffic is so dense as to necessitate 40 booked trains to and 40 from the City per hour, and the automatic signalling dealt with these successfully. Similar signalling was therefore installed between Baker-street and Neasden in 1911, the number of signalling sections being increased from 24 to 51. At this date there was only one through line at Baker-street dealt with by two signal boxes, one at the north end of the station and one at the Circle end. This through line was track circuited and full protection was afforded to train movements, allowing 48 through passenger trains to be run to and from the City. All the current used in these installations was continuous.

In 1913 the new Baker-street Station was completed, and automatic signalling was installed between the Circle lines and the north end of the station. For this purpose a small signal box was constructed on a retaining wall so as to be out of the way, and in it a power frame of 36 levers (6 spare) was installed. This power frame deals with over 1,500 trains a day, and it is interesting to note that the signalman has no view of the trains except those within station limits immediately in front of his box. Through the station all signals and points are controlled by direct current, but the track circuits are alternating current. In 1913 also two new fast lines were constructed alongside the old or local lines from Finchley-road to Wembley Park, a distance of 5 miles. Through the junction at Finchley-road and on to Wembley Park alternating current track circuits were installed, but the signals are worked by direct-current as far as Neasden Power House. From this point to Harrow-on-the-Hill alternating current is used for the signals as well as for the tracks, and from the same point alternating current is used both for tracks and signals on the local lines to the junction north of Wembley Park Station where the fast and local lines converge. From Baker-street to Harrow-on-the-Hill, before automatic signalling, there were 39 signalling sections, now there are 69, and on the through fast lines there are 20 sections.

In 1919 the signalling from Praed-street Station to South Kensington, which was an automatic bar and treadle system controlled by direct current, was track circuited with alternating current, but the signals continue to be controlled by direct current.

Current for the supply of power to operate the power frame at Praed-street Junction and at Baker-street is obtained from two 130-volt, 5-kw. motor-generators through suitable cables. These supply power for the operation of the points, the signal lamps and train stops, the electro-magnets for back-locks and for the constant indication of power-worked points at Praed-street Junction, and also for working the power frame at Baker-street, the total required for both boxes being 2·08 kw.

For operating the track circuits, automatic and semi-automatic signals, and train stops, between Praed-street, Bishop's-road and Edgware-road Stations, and also between Edgware-road, Great Portland-street and Marlborough-road, and for the four large illuminated train indicators at Baker-street, power is obtained from one 15-kw. and two 12-kw., 70-volt motor generators in Baker-street sub-station, and the maximum power taken is 14 kw. The mechanical locking in the power frames is ordinary miniature tappet locking controlled by levers in the ordinary way, the electric locking frame being behind the levers. Illuminated continuous diagrams are placed behind the frames lighted by 75-volt, 5-candle-power lamps.

All signals at junctions are electrically back-locked, an important safety device which in the further development of electric signalling has enabled point-locking bars to be dispensed with. At all running stop signals there are train stops which are not connected to the signals mechanically, but electrically, and are controlled by the track circuits in the same manner as the signals, coming to clear and going to danger with the signal. They are also controlled by the track circuit independently of the signal, so that, if a signal failed to go to danger, the arm of the train stop would still go to the danger position.

All electric signals are either automatic or semi-automatic, the former controlled through the track circuits by the passage of the trains themselves, the latter controlled from the signal box when this is in use, but becoming automatic when not so controlled. Inside tunnels the signals are lamp signals, outside they are upper quadrant semaphores worked by electric motors. Signals are held normally in the clear position by electric power, they go to danger by gravity. All signals are lighted electrically, and stationmasters light the signals half-way to the next station on either side by a switch at their station. One hundred yards behind each stop signal in the open fog repeater signals have been erected, the lights of which are placed at the level of the driver's eyes and as near as possible to the running line. By this means an indication is given to the driver whether the stop signal ahead is at clear or at danger, and if at danger he can slow up and avoid being tripped suddenly. The signalmen have fog repeater switches in the signal box by means of which they can light the fog repeater lamps when necessary.

Between junctions it is possible to have a number of trains—*e.g.*, between Finchley-road and Baker-street it is possible to have 10 trains, and Mackenzie Holland and Westinghouse Company's magazine train describers were installed, by which the signalman at Finchley-road is enabled to indicate to the Baker-street signalman whether a train terminates there, or is a through train to the City. All points where there are power frames are worked by the Mackenzie Holland and Westinghouse all-electric point machines. These machines are enclosed in a water-tight cast-iron case divided into three compartments. At one end is the motor, in the centre are the gear wheels and motor switches, and in the other end the worm drum that operates the points and the bolt that locks them both ways. Both point blades, as well as the bolt lock, are individually detected through an electric detector fixed in the 4-ft. way before the signalman can get his signal for a train to pass over that route. These point machines are most successful.

The track relays at Baker-street are of the single element vane type, the shunt by a train averaging 0·9 ohms. The relays used on the direct-current system are of the three-coil polarised type, the shunt of which by a train averages 0·15 ohms. Where alternating current is used the track relays are of the two element galvanometer type and the shunt of these by a train averages 0·6 ohms. The most recent type of relay used is a two-element vane relay, the shunt of which by a train averages 3·4 ohms. The cost of maintenance of this system of signalling is not excessive. Before automatic signalling was installed there were 645 levers in use, whereas at present only 311 levers are in use, while the number of signalmen was reduced from 86 to 27½. This meant in 1908 a saving of 127*l.* per week in signalmen's wages, which at the present date would amount approximately to 325*l.* per week. During 1920 the whole cost of maintenance—wages and materials—of the signalling of the electrified lines amounted to 123*l.* per route mile.

Charts have been kept from the commencement of automatic signalling in order to ascertain the number of delays to trains as compared with delays to trains with ordinary signalling, and the comparison comes out very favourably to automatic signalling.

Tests have also been made with a three-position light signal as used on the Pennsylvania Railway in the United States of America. The cost of maintenance is about the same as with two-position semaphores, but the light signal would appear to have advantages in some respects, *e.g.*, the entire absence of mechanical parts, and in the power of penetration of the light rays both in sunshine and in fog.

* Abstract of a paper read before the Institution of Civil Engineers, Tuesday, March 21, 1922.

PERSONAL.—Electric Control, Limited, announce that after April 1, 1922, their London office address will be: Hastings House, Norfolk-street, Strand, W.C. 2.

THE LATE DR. ING. REINHARD MANNESMANN.—Reinhard Mannesmann, who died in his native town of Remscheid, in Rhenish Prussia, on February 20, was the oldest of six sons of the late Reinhard Mannesmann. The father was a successful manufacturer of tools, and all the six sons became engineers of some note; Reinhard himself and his brother Max were, in 1885, the inventors of the process of making seamless steel tubes, which has made the name famous. Born in 1856, he was educated at Düsseldorf, and took his diploma in the Mining Academy of Berlin on the strength of his researches on the relations between pure carbon and pure iron with rising temperatures. He left the Mannesmann Röhren Werke, which were started at Düsseldorf, as early as in the middle of the 'nineties; he was then interested in the improvement of suspended incandescent mantles. In 1907 he transferred his main activities to Morocco, both as mining engineer and coloniser. In the former connection in particular he came into conflict with French interests, and the war wrecked his schemes completely; he had founded a Morocco-Mannesmann Compagnie, which had headquarters in Hamburg, and a Mannesmann Industrie und Handels-Gesellschaft in Berlin. Ever ready to help, and to the fore when danger threatened, he was a man of broad interests and widely popular. He leaves a widow and four daughters.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Rustless Iron and Steel.—Systematic investigations into the greater possibilities of stainless and rustless materials have produced valuable results which are already being employed in the latest engineering developments. In addition to rustless iron, malleable stainless steels are being manufactured on a commercial basis, and are now in almost general use for the making of turbine blades. A certain amount of rustless iron is going into consumption in the building and domestic utensil trades, but the obstacle of excessive cost, due to the current dearness of carbon-free ferro-chromium, requires to be surmounted before rustless iron is in universal vogue. Expert metallurgists state that the new malleable stainless steels, which are available in sheet form, have a great future, and the trend of current research leads them confidently to believe that economic developments will run parallel with scientific development.

Iron and Steel.—The prospect of increased activity in the armament trades has been brought nearer as a result of the London negotiations in which the Lord Mayors of Sheffield and other large centres have taken part. It is expected that work on a minor scale will be expedited in connection with the construction of the two capital ships. This will assist in reducing Sheffield's abnormally large total of 50,000 unemployed (excluding those dislocated by the engineering lock-out). At the same time the total amount of work that is expected will not be sufficient to employ anything like the whole of Sheffield's armament-producing resources. Consequently the future of a big section of this expensive plant is under consideration. Though the engineering trouble has caused only sectional dislocation, its effect on contract developments has proved serious, and has considerably delayed progress in arranging for forward deliveries. There is a certain amount of work in hand for the construction of steel works plant on Continental and Colonial account, and orders for minor quantities of railway tyres, axles and springs are under execution. One of the most hopeful features is the improved demand for steel billets and hematite iron, though the increase in output of the latter is due almost solely to foreign requirements. Despite Germany's increased purchases of steel scrap at considerably higher rates than are offered by local steelmakers, one of the largest scrap-dealing firms with headquarters in Sheffield has decided to close several of its shipbreaking yards, because of the existence of surplus stocks. Business in the lighter trades is slightly more active. Dominion markets are taking rather larger quantities of hand tools. Big opportunities are presented by the needs of South American buyers, if prices can be adjusted to meet reduced purchasing power.

South Yorkshire Coal Trade.—The steam coal market reflects the damaging effect of the engineering trouble, home industrial requirements having been still further restricted. Collieries are largely dependent on export requirements. The further accumulation of stocks has compelled short time working. Forced selling has resulted in slacks, due to the increased tonnage under load. Official quotations are being cut to secure spot business. Both the gas fuel and house coal markets are easier. Big inroads have been made into orders. Metropolitan consumers are buying sparingly in anticipation of lower rates. Quotations:—Best branch hand-picked, 38*s.* to 39*s.*; Barnsley best Silkstone, 36*s.* to 37*s.*: Derbyshire best brights, 32*s.* to 34*s.*; Derbyshire best house coal, 32*s.* to 34*s.*; Derbyshire best large nuts, 28*s.* to 30*s.*; Derbyshire small nuts, 17*s.* to 19*s.*; Yorkshire hards, 23*s.* to 24*s.*; Derbyshire hards, 21*s.* 6*d.* to 22*s.* 6*d.*; rough slacks, 14*s.* to 15*s.*; nutty slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; smalls, 2*s.* 6*d.* to 6*s.* 6*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Demand for Cleveland pig-iron is decidedly quieter, but the output is very limited, and the output of the six blast furnaces that are making Cleveland sorts is well taken up. It is still difficult to purchase for prompt delivery, and values, which producers declare are altogether unremunerative, are fully maintained. Fairly good sales of mottled and white iron have rendered these inferior grades much less plentiful, and firmer in price. Makers are under no price restriction as regards mottled and white, and they quote up to 80*s.* for them. The other qualities are fairly well sold, and producers adhere to their agreed-on home and export minimum rates of 95*s.* for No. 1, and siliceous iron, 90*s.* for No. 3 G.M.B., 87*s.* 6*d.* for No. 4 foundry, and 82*s.* 6*d.* for No. 4 forge.

Coke.—There is a slightly quieter feeling in coke. Medium blast-furnace Durhams may be put at 29*s.* delivered.

Hematite.—East Coast hematite continues in very good request, and purchases for early delivery are difficult to arrange, so well sold are manufacturers. Notwithstanding increased output by the blowing-in of more furnaces, makers have little iron to offer for supply before towards the end of next month. Inquiries on German account continue, and include a rather urgent one for 1,500 tons; while further shipments of some 2,000 tons to Germany against contracts already entered into, are being made this week. Nothing below 100*s.* f.o.t. and f.o.b. is named for Nos. 1, 2 and 3; and No. 1 hematite is quoted a shilling above mixed Nos.

Foreign Ores.—A little business is passing in foreign ore, but transactions are almost entirely confined to dealings in supplies from the Mediterranean which

are relatively a good deal cheaper than Spanish ores. Best rubio is round about 27*s.* c.i.f., whilst quite 5*s.* below that figure is stated to have been accepted for Mediterranean ore.

Manufactured Iron and Steel.—There is not much new to report concerning finished iron and steel. The situation generally is unsatisfactory and the outlook discouraging, but some little consolation is derived from the fact that high cost of production in Germany is prohibiting successful competition of manufacturers in that country, in certain markets. There are fairly good inquiries for sheets and for constructional steel. There is hardly such keen undercutting for foreign orders as there has been, but export business can still be transacted at substantially below the following recognised home quotations:—Common iron bars, 12*l.*; iron rivets, 14*l.*; soft steel billets, 7*l.* 10*s.*; medium steel billets, 8*l.* 15*s.*; hard steel billets, 9*l.* 5*s.*; steel boiler plates, 14*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; steel joists, 10*l.* 10*s.*; heavy steel rails, 9*l.* 10*s.*; fish plates, 14*l.* 10*s.*; black sheets, 12*l.* 10*s.* to 13*l.*; and corrugated galvanised sheets, 16*l.* 5*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Once again it is found necessary to report practically no change in the Scottish steel trade over the week. The great scarcity of specifications is being severely felt all round and much plant is standing idle in consequence. Buyers continue to hold aloof and little enterprise is being shown. The general outlook at the moment is not encouraging and few can see far ahead because of the unsettled state of the industrial world. The possibility of a stoppage in the shipbuilding trade has militated against the demand for ship plates and sections and only small lots are going through. In the black sheet trade a dullness certainly prevails despite the fact that there are a few works fairly well employed. Export of all kinds is poor, although selling departments have been doing everything possible to secure new contracts. Prices are without change and are as follow: Ship plates, 10*l.* 10*s.* per ton; boiler plates, 14*l.* per ton; sections, 10*l.* per ton; and black sheets, 11*l.* 15*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The malleable iron trade of the West of Scotland is moving along very slowly at present and bookings all over are very small. With so many of the engineering works almost wholly closed down, and the shipbuilding industry faced with a possible stoppage also, there is very naturally little confidence on the part of buyers, and things are meantime hanging fire. The price of "crown" bars for the home market is 11*l.* 10*s.* per ton, with export called 11*l.* to 11*l.* 5*s.* per ton, but there is little doing in the latter.

Scottish Pig-Iron Trade.—A very dull tone prevails in the pig-iron trade of Scotland, and only a small amount of business is passing. The hopes raised recently that brighter times were approaching have been dashed to the ground by the present trouble in the labour market, and it is rather difficult to estimate even roughly when the trade may take a turn for the better. Hematite keeps firm at 5*l.* 7*s.* 6*d.* per ton, delivered at the steel works, but foundry iron is the turn easier, and the prices may be taken at 5*l.* per ton for No. 1 grade, and 4*l.* 15*s.* per ton for No. 3 grade, both in trucks at maker's works. In the export side of the trade there is a moderate amount going through.

THE ROYAL SANITARY INSTITUTE.—The Institute announces that the Henry Saxon Snell prize for the current year will consist of 50 guineas and the medal of the Institute; it is offered for an essay on "Improvements in the Sanitary Appliances and Fittings for new Housing Schemes, having regard to Efficiency and Economy." The conditions can be obtained from Mr. E. White Wallis, Secretary, 90, Buckingham Palace-road, London, S.W. 1.

THE LATE DR. JOHN THEODORE MERZ.—We regret to have to announce the death, which occurred last Tuesday, the 21st inst., at "The Quarries," Grainger Park-road, Newcastle-upon-Tyne, of Dr. John Theodore Merz, Ph.D., D.C.L., LL.D. Dr. J. T. Merz was born in Manchester in 1840, and was the son of the late Dr. Philip Merz, who was headmaster of Chorlton High School. He was educated in this country and in Germany. Dr. J. T. Merz was first—in 1867—with Townsend's Chemical Works, Glasgow; in 1868 he entered the Tharsis Sulphur and Copper Company, Hebburn, and shortly afterwards was appointed general manager of the Tharsis Works at Birmingham, Glasgow, Hebburn and South Wales. Dr. J. T. Merz was one of the pioneers of the industrial application of electricity to lighting, power and transport, and as early as 1881 he was associated as a director of the Swan Electric Light Company. He also took a most active interest in the foundation of the Newcastle-upon-Tyne Electric Supply Company, and in 1901 he succeeded the late Alderman T. G. Gibson as chairman of that important undertaking. He retired from the chairmanship in 1916, at a time when the company's system covered an area of about 600 sq. miles, and had a total cable mileage of 377 miles. He continued as a director and vice-chairman of the company up to the time of his death. Dr. J. T. Merz was also actively interested in several other companies, and was intimately connected with Armstrong College almost since its foundation. He has written largely on scientific and philosophical questions. He is survived by his wife, a daughter, and two sons, one of the latter being Mr. Charles Hesterman Merz, the well-known electrical engineer and senior partner in the firm of Merz and McLellan.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The official figures of the Customs show that the volume of coal exports from South Wales in February were in excess of the average rate of shipments in January. In all, 2,158,572 tons of coal was shipped as cargo and bunkers compared with 2,233,521 tons in January. Actually there was a decrease of 74,949 tons in the February shipments, but this was due to the fact that there were two less working days than in the previous month. Shipments in January and February are shown in the following table:—

	January. Tons.	February. Tons.
Cargo	1,861,105	1,781,894
Bunkers	372,416	376,678
Totals ...	2,233,521	2,158,572

Compared with February of last year shipments in the past month showed an increase of 1,067,510 tons, or were double the quantity shipped in the corresponding month of a year ago. The annual reports to December 31 last of nine South Wales Colliery companies, with a share capital aggregating 10,500,000*l.*, shows that the profits for that period totalled only 451,000*l.*, compared with 1,620,000*l.* in the previous twelve months. Seven of the companies showed profits in the past year, but two sustained losses. Compared with a year ago profits were reduced by 1,168,000*l.*, representing a reduction of 73 per cent., while dividends were halved or entirely passed.

More Shipping Companies Fail.—Shareholders in the Glynn Shipping Company, Cardiff, have been advised that an extraordinary meeting will be held when a resolution will be proposed for the winding-up of the company. At the close of last month shareholders were informed that the mortgagees had exercised their rights and taken possession of the company's steamer Woldingham, of 5,250 tons deadweight. Shareholders in the Turner Steam Navigation Company, Limited, Cardiff, which was formed in February, 1920, have also been advised that mortgagees have taken possession of the company's steamer Torquay, of 1,050 tons deadweight, and a meeting has been called to propose the voluntary winding-up of the company.

CONTRACTS.—The London County Council have given the contract for the supply of foundry plant to their Central Car Repair Depot, to Messrs. Alldays and Onions, Limited, Great Western Works, Birmingham. This firm is probably the oldest engineering one in the Kingdom, having been established in 1650.

DUPLICATION OF LINES, BRAZIL RAILWAYS.—A despatch has been received at the Department of Overseas Trade from the Commercial Secretary to H.M. Embassy at Rio de Janeiro, drawing attention to a Decree, No. 4,395, dated December 16, published in the *Diario Official*. The Decree authorises the Executive Authority to open at the Ministry of Ways and Public Works a special credit of 4,700,000 milreis (approximately 155,000*l.* at present rate of exchange) for the duplication of certain lines of the Central Brazil and North-Western Brazil Railways.

ROYAL METEOROLOGICAL SOCIETY.—The usual March lecture of this society was delivered on Wednesday, the 15th inst., at 49, Cromwell-road, by Dr. E. M. Wedderburn, O.B.E., F.R.S.E., the subject being "*Seiches and the Effect of Wind and Atmospheric Pressure on Inland Lakes.*" The president of the society, Dr. C. Chree, F.R.S., was in the chair. The following is an abstract of the lecture: "Seiche" is the name originally given in Switzerland to quasi-tidal movements of the level of inland lakes. The study of these began about the year 1730 in Lake Geneva, but their character as standing oscillations of the water in the lake was not recognised until Forel began his classical series of observations in that lake in 1869. At a much earlier date it had been realised that there was an intimate connection between these movements and atmospheric pressure. In 1905 the late Professor Chrystal made a careful study of the seiches in Loch Earn for the Scottish Lake Survey. Simultaneous observations with a Dines-Shaw microbarograph enabled him to discuss the effect of small barometric disturbances with much greater exactitude than had previously been possible, and he was able to show that microbaric disturbances were the most frequent cause of seiches. Other possible causes appear to be heavy rainfall over part of the lake, rapid flooding and wind squalls. Earth tremors appear on occasion to have caused considerable movements, but this is an unusual cause. The Scottish lake survey also discovered the existence of internal seiches of large amplitude. During autumn in all lakes of considerable depth there is at the surface a layer in which there is little variation of temperature with depth. At the foot of this layer there is another narrow layer, called the discontinuity layer, in which the fall of the temperature is rapid, while below this is the bottom water of the lake in which temperature variations are small. The effect of a wind blowing along a lake is to accumulate the warm surface water at the lee end, so that the discontinuity layer is displaced from its normal horizontal position. When the wind ceases or moderates a standing oscillation commences at the discontinuity layer, which is the surface of separation, between the top and bottom layers. The period of oscillation depends on the difference of density between these layers. The oscillation may be of large amplitude, many feet, without measurable disturbance of the level of the free surface.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, March 24, at 8 p.m., at Caxton Hall, Question and General Discussion Meeting.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, March 24, at 6 p.m. Continuation of the discussion on Mr. Dewhurst's paper on "British and American Locomotive Design and Practice."

THE ROYAL SOCIETY OF ARTS.—Monday, March 27, at 8 p.m.: Cantor Lecture, "The Constituents of Essential Oils," by Mr. L. Guy Radcliffe, M.Sc.Tech., F.I.C., Lecturer in Applied Organic Chemistry, College of Technology, Manchester (Lecture II); Wednesday, March 29, at 8 p.m., Ordinary Meeting, "Alcohol in Relation to Industrial Hygiene," by Sir Thomas Oliver, LL.D., D.Sc., M.D., F.R.C.P. Sir Robert Armstrong-Jones, C.B.E., M.D., F.R.C.P., will preside.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, March 28, at 8 p.m., Meeting at the House of the Royal Society of Arts, John-street, Adelphi, London. Discussion on "The Lighting of Public Buildings; Scientific Methods and Architectural Requirements." An account of Experimental Work and Results will be presented by Messrs. E. H. Rayner, Sc.D., J. W. T. Walsh, M.A., M.Sc., and H. Buckley, B.Sc., of the National Physical Laboratory. Some examples of the Lighting of Decorative Interiors will be shown.

THE ROYAL AERONAUTICAL SOCIETY.—Thursday, March 30, at 5 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. A paper entitled "The Design of a Commercial Aeroplane" will be read by Captain G. de Havilland.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, March 30, at 6 p.m., in the Lecture Theatre of the Institution, Savoy-place, Victoria Embankment, W.C. 2. "Applications of Electricity to Agriculture" (with cinematograph film), by Mr. R. Borlase Matthews.

THE NEWCOMEN SOCIETY.—Thursday, March 30, at 5 p.m., at the Institute of Marine Engineers, 85 to 88, Minories, E. 1 (nearest station, Mark-lane). Paper by Engineer-Commander E. C. Smith, O.B.E., R.N., Member, on "The Centenary of Naval Engineering, A Review of the Early History of our Steam Navy."

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, March 31, at 8 p.m., at Caxton Hall. Lecturette, "The Steel-Melting Shop," by Mr. D. P. Dickinson (Member). Slides.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, March 31, at 9 p.m., a discourse will be delivered by Mr. Arthur B. Walkley, B.A. The subject is "Jane Austen." Afternoon Lectures, at 3 p.m.: Tuesday, March 28, Mr. John W. Evans, D.Sc., F.R.S., M.R.I., on "Earth Movements" (Lecture I); Thursday, March 30, Mr. Arthur M. Hind, O.B.E., M.A., on "Landscape Etchers: New and Old" (Lecture I); Saturday, April 1, Sir Ernest Rutherford, LL.D., D.Sc., F.R.S., M.R.I., Professor of Natural Philosophy, R.I., on "Radio-activity" (Lecture V).

THE WEST BROMWICH ENGINEERING SOCIETY.—Friday, March 31, at 7.30 p.m., at the Technical School, West Bromwich, a paper on "Internal-Combustion Engines" will be read by Mr. J. Robson, Chief of the Gas and Oil Engine Department, Messrs. Tangyes, Limited. Mr. John W. Allin, Engineer and Manager, Albion Gas Works, will preside.

GREENOCK PHILOSOPHICAL SOCIETY.—The Watt Anniversary Lecture on "Some Aspects of Industry and Economics," will be delivered to-day by The Right Hon. Lord Weir of Eastwood, LL.D., late Director of Aircraft Production, at Museum Hall, at 8 p.m.

INSTITUTE OF TRANSPORT.—The Council of the Institute of Transport announces that it will undertake suitably to celebrate principal events in transport history and, in this connection, will arrange for celebrations of the centenaries of the opening of the Stockton and Darlington Railway in 1825, and of the locomotive trials at Rainhill in 1829, of the "Rocket," by George Stephenson.

THE BRITISH CAST-IRON RESEARCH ASSOCIATION.—The Director of Research, in his monthly report, states that during the month of February a further number of problems of varied character have been submitted for investigation and research. Most of these are of general interest and importance; it is again noticeable that the troubles incidental to shrinkage and uneven contraction are widespread in both the grey iron and malleable branches of the foundry industry. Help has been desired in the manufacture of ingot moulds, annealing pots, and of castings subject to vibration and coincident fluctuations of heat. Members have received assistance in the following problems: The design of cupola linings and ladles; the influence of deoxidisers in metal for light castings subject to repeated heatings; the overcoming of erosion defects in centrifugal pump casings and impellers; suitable mixtures for bearings to carry hot running shafts; the function of moisture in cupola coke; mixtures and treatment suitable for malleable castings to carry superheated steam of high pressure. In addition to the above everyday type of inquiries, work has continued in the direction of accumulating further data necessary for the carrying out of the fundamental research problems in hand. In this connection the director has been helped by the receipt of actual examples of defective castings, designs and particulars of manufacture from a number of the members.

4½-CUBIC YARD SIDE-TIPPING WAGON.

CONSTRUCTED BY MESSRS. RUSTON AND HORNSBY, LIMITED, ENGINEERS, LINCOLN.

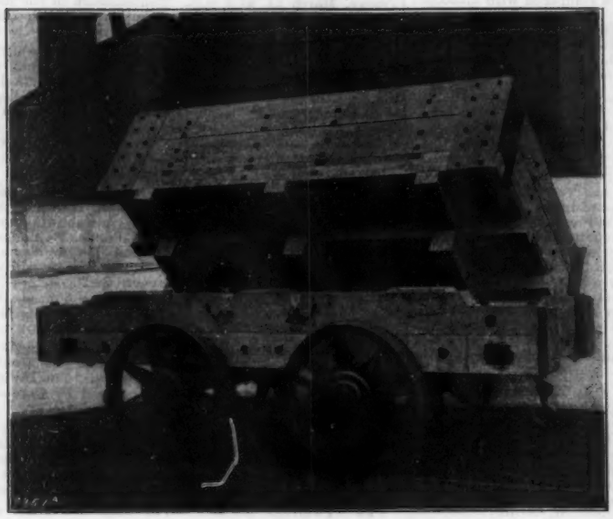


FIG. 1.

FIG. 2.

Fig. 3.

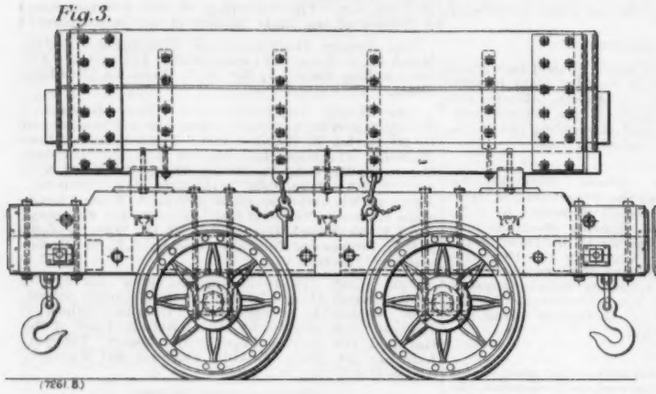
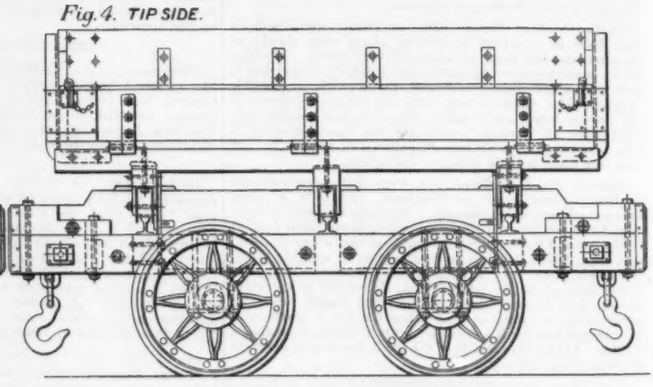


Fig. 4. TIP SIDE.



A NEW model of contractors' side-tipping wagon which is being built by Messrs. Ruston and Hornsby, Limited, of Lincoln, and 46, Queen Victoria-street, E.C. 4, is illustrated above. The wagon, which the makers term of their Ship Canal type, has a capacity of 4½ cub. yards, the internal dimensions being 10 ft. long by 6 ft. wide by 2 ft. 2 in. deep. The ends taper in 6 in. from the tipping doors to facilitate the emptying of sticky material. The general design of the wagon will be followed from the illustrations which require comparatively little comment. It is constructed of heavy section hardwood, bolted together and reinforced by steel-strengthening plates where necessary. The tipping gear consists of three curved rockers working on three flat-bottom rails. The rockers are supported on the main cross-beams of the frame, thus ensuring the proper distribution of the weight of the body when tipping. The body is balanced to ensure tipping immediately on release of the catch, and can be brought back to its normal position by one man. The gauge of the wagon shown in our illustrations is 4 ft. 8½ in., but other gauges can be supplied as required. Railway type wheel and axles are fitted, the pedestals being of cast-iron with renewable chilled bearings.

Fig. 5.

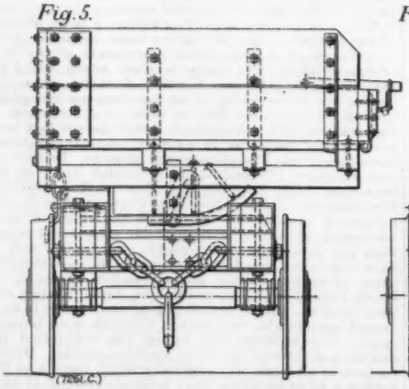
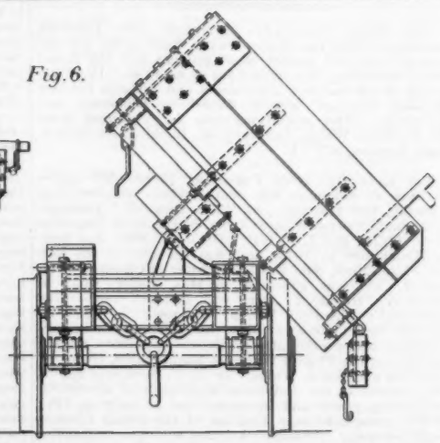


Fig. 6.



WORKING HOURS IN GERMAN INDUSTRIES.—The actual working hours in German factories are in the main regulated by the law of November 27, 1918, which admits of considerable latitude in interpretation. The working time, including certain rest periods, is eight hours; details are left to agreement between the employers and the delegates of the employees. Saturday may be a short day, the hours lost being spread over other days. Where work is continuous all male workers above 16 years of age may, once in every three weeks, be called upon for 16 hours' duty to get over the shifts; this may also apply to female workers, but females must have 16 hours' rest after such work, and they are not to be kept at work after 10 p.m. In these cases the mid-day interval of half an hour may be prolonged to one hour. The rules are not binding for occasional workers, nor for emergency work. These regulations of 1918 were, according to a report by DR. C. Duisberg, of the Elberfeld Farbwerke, at once adopted in the chemical industry on the Rhine, where the eight hour day had already been introduced by many firms. When three shifts are the custom, they commence at 5.55 a.m., 1.55 p.m. and 9.55 p.m. and end five minutes after 2 p.m., 10 p.m. and 6 a.m. Before the war the working day had consisted of 8, 9 or 10 hours, sometimes even 12 hours, and the chief argument of the masters against the 8-hour day had been that most other countries kept longer hours. In some German factories the 7-hour day is now the rule. Thus in the Jena glassworks work begins at 7 a.m. and stops at 2 p.m., leaving the employees a free afternoon and evening which is much appreciated. This is said to answer well. The same hours are observed in some offices; in others the hours 8 a.m. to 4 p.m. are preferred. Shop hours vary largely. A complete break at midday for 1½ hours or so, which was very common before the war, also in Switzerland, has not quite disappeared yet, though the arrangement often involves a very great waste of time and much inconvenience to clients.

ENGINEERING.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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Two-Page Plate.—LOW-TEMPERATURE ROTARY CARBONISING PLANT.

ENGINEERING.

FRIDAY, MARCH 24, 1922.

SCIENCE AND PRACTICE.

WE believe it was the late Professor Perry who was the first to call attention to the modernity of Mr. Wackford Squeers' theory of education, which he summed up as follows: "When a boy knows this out of a book, he goes and does it." As Professor Perry pointed out, this is the ideal aimed at in many of our most progressive technical schools. It is not, of course, universally accepted. The famous Ecole Polytechnique is, we believe, wholly devoted to mathematical studies, although the engineers for the Département des Ponts et Chaussées are wholly recruited from the students of this historic establishment. In this instance, however, the pupils who elect for one or other of the technical services open to them take a further course at special schools before actually commencing their professional career. This is not the case, however, with the Ecole Centrale des Arts et Manufactures, from which the engineering staffs of the principal industries are recruited, which affords its pupils no opportunity of obtaining practical knowledge. This arrangement is, in fact, very general on the Continent, and has probably been no small factor in enabling us in this country to play the part we have done in the competition for international trade. From his address to the Engineering Society of the University of Southampton Engineer Vice Admiral Sir George Goodwin, Engineer-in-Chief of the Fleet, would appear to be a firm believer in the alternative system in which theory and practice go hand in hand. His especial concern has been, of course, the training of engineering recruits for the Navy, and for such a career the plan has undoubtedly many advantages. Too often, as Sir George remarked, the student with a taste for theory is tempted to despise ability in the handling of tools, whilst his rival is apt to deride him as a mere *x* chaser, and the two classes tend to drift apart. This Sir George deplores, and no doubt a Naval Engineer should be fairly adept in both departments. The mere mechanic absorbs in the course of his work a very intimate and peculiar knowledge of the properties of the materials with which he has to deal, but, owing to his lack of theoretical knowledge, can seldom be trusted to deal with novel conditions. On the other hand, in a breakdown of an ordinary type the experienced mechanic will have the repairs almost completed before the *x* chaser pure and simple has made up his mind as to the first steps to be taken. At sea the engineers have to rely on themselves, and, in consequence, Sir George is undoubtedly right in insisting on the great importance of combining theory with practice. In the dockyards, conditions are somewhat different. In the scheme for training apprentices which is there is vogue, an early distinction is made between those who show promise of being able to excel in theoretical studies and those who are fitted to be mechanics only. The former class have given us our unrivalled corps of naval constructors.

Of course, the highest standard in craftsmanship is never attained by one who is not gifted with more than the average amount of brains, but men who are capable of attaining this standard are rare and are, perhaps, found as often amongst amateurs as amongst professionals. Some of those responsible for the most exact measurements of physical constants have found themselves compelled to do the most refined mechanical work themselves. The mechanics entrusted with the task of completing the sliding surfaces of the machine used for measuring the wave length of cadmium light proved unequal to the task of securing the accuracy necessary, and the final finish had to be given by the physicists themselves. Sir George very rightly insisted on the importance of science to industry. It is but seldom, however, that a discovery made in the study or the laboratory is of immediate practical value. A notable exception to this rule was the invention of the Michell thrust bearing, without which or some equivalent, Sir George said, the construction of the Hood would have been impossible. In fact, had thrust blocks of the ordinary type been used these would have had to have been over 20 ft. long, and it would have been practically impossible to secure an even distribution of the load between the different collars. Instances of this kind are, however, exceptional. In general, as with Faraday's discovery of electro-magnetic induction, the immediate monetary or practical value is nil. The discovery constitutes merely the seed of the future developments, and unless taken up by men prepared to risk both their labour and their capital, will never germinate. Another instance is afforded by Edison's discovery that a current might pass between the filament of a glow lamp and a third electrode sealed into the same bulb. At the time it was made this observation was merely a scientific curiosity, but it constituted the first step towards wireless telephony.

During mediæval times industries were carried on without assistance from the natural philosopher. The craftsmen knew from actual experience an enormous number of scientific facts but these were unco-ordinated and had to be learnt afresh as isolated facts by each new recruit to the trade. The march of improvement was accordingly slow. In fact, it has been suggested that under such conditions we may assume that the progress is proportional merely to the square root of the effort expended, whilst under the guidance of an adequate theory improvement should be directly proportionate to the endeavour. This view, based on the mathematical theory of probability, is perhaps too severe on the Middle Ages and too optimistic as regards the present time. Even at the darkest, attempts at betterment were seldom made wholly at random, whilst as regards conditions to-day there are few theories so satisfactory and complete as to entirely eliminate the need for experiments made more or less at random.

In civil engineering work generally the Roman engineer could have learnt but little from his successors of many centuries later. In the arts and crafts greater progress had been made, but in this, as we have above observed, science played but a small part, and even as matters stand to-day there is little scope for its application to the ordinary routine

of the workshop. The needs of the moment are for the most part adequately met by the teachings of experience, but those of the future will hardly be satisfactorily solved without the aid of science. An eminent and successful engineer has declared that a firm, if it means to hold its own, should spend from 1 per cent. to 3 per cent. of its yearly turnover in experimental work.

Sir George Goodwin referred to the refusal of certain firms to allow their apprentices an adequately varied experience. Such firms are hardly playing the game. Skilled mechanics we must have, and all should do their fair share in training them. At times, too, when experimental work is undertaken every effort is made to keep the purport and results from the assistants. The training of the latter is correspondingly narrowed, and when later on some important post falls vacant, it has to be filled by an alien attracted from outside. Unless our young men are afforded the opportunity of widening their experience, the supply of those capable of successfully filling responsible positions will be restricted. In this matter some of our railway companies hold very sound views. In one case a new general manager was told by the board on his appointment that his most important duty was to train up young men capable of succeeding him.

With regard to technical education generally, we are inclined to think that there is an increasing tendency towards specialisation. Possibly it is to some extent unavoidable. Under present conditions there is a demand that youths direct from college shall be capable at once of rendering service of real value, and hence it is necessary that he should choose at once and specialise in some particular department of engineering. Thirty years ago the pressure was less insistent, and we fancy that students left with a broader basis of knowledge than is now usual. Sir George Goodwin would seem to be somewhat of the same opinion and to be desirous of widening the range of studies, particularly by making compulsory some knowledge of metallurgy, the importance of which is being accentuated daily.

PARLIAMENT AND THE ENGINEERING DISPUTE.

THE debate in the House of Commons on the Engineering Dispute has served at least to demonstrate the unsuitability of the political arena and its atmosphere for calm and judicial investigation of the causes of particular trade disputes. The real facts are best known by the parties directly involved, and the House must have found it difficult to disentangle them from the irrelevancies, the personalities and the misleading statements which were not absent from the debate. One thing, however, must have been plain to the House, viz., that the matter really in dispute was managerial rights and not overtime. Mr. Clynes touched on overtime at the commencement of his speech, but soon passed to the main question of the relation of the workers' rights to the right of management claimed by the employers. Having developed this thesis he renewed his appeal to the Minister of Labour to set up a Court under the Industrial Courts Act to enquire into the dispute.

Dr. Macnamara, in his reply, maintained his refusal to come to any decision on this point while the present ballot of the various unions was in progress. Mr. Hopkinson tilted, after his fashion, at both sides. Mr. Gould, referring to the intolerable conditions which were being imposed upon employers in their daily work by the unions, said that lines of demarcation, disputes as to how many men should be put on a machine, overtime conditions, &c., were being brought up from day to day, and the employers were being checked and retarded by every possible kind of opposition while they were spending money on new plant and machinery and doing all they could to get output and avoid disputes. Colonel Wedgwood essayed the role of prophet with unfortunate results, for immediately after he had prophesied that the employers' case would not be stated in the House—a prophesy which ignored Mr. Gould's statement—Sir Allan Smith rose to complete the employers' case.

Sir Allan made it clear to the House that certain unions had indicated clearly to the employers that for the last twelve months they had made up their minds that the employers were no longer to have the rights of management which they have had in the past; and he showed that the employers, far from desiring to attack the unions, had been forced to take up this challenge as soon as it became evident. He pointed out that the employers had no desire to work overtime where it could be avoided, if for no other reason than that it was not economic to pay men 50 per cent. extra for working at the end of the day when their energies were greatly diminished. He repudiated emphatically the suggestion that the employers wished to destroy the unions, and referred to Mr. Brownlie's acknowledgment that such a suggestion was unwarranted. He said that he, personally, desired that the unions should become stronger, provided their internal discipline were improved so that the workmen should in future accept the recommendations of their appointed leaders instead of turning them down as they had done in the present case with such unfortunate results. As regards the call for a Court of Enquiry he pointed out that no such Court could be in as good a position to form opinions as to the proper relations of the engineering employers and employees as the conference of November 17 and 18, 1921, at which the unions conceded that they should not interfere with the right of the employers to exercise managerial functions in their establishments, and that the instructions of the management should be observed pending discussion of any question in dispute.

Towards the close of his speech Sir Allan gave an important indication of the employers' desire to be reasonable in all things by saying: "If the unions are prepared to agree with us in principle that we are still to have the right to manage our factories, we shall be more than pleased to sit down with them in conference while their men are at work, in order to come to an agreement with them as to the manner in which these managerial functions are to operate." Out of the strong came forth sweetness, and at the moment of writing we wait to learn whether any good thing will come of the conferences which have followed on this declaration.

UNBALANCED RUDDERS OF SINGLE-SCREW STEAMSHIPS.

A PAPER on unbalanced rudders of single-screw merchant ships was read, on Tuesday, the 14th inst., before the Institution of Engineers and Shipbuilders in Scotland by Mr. G. S. Baker and Mr. G. H. Bottomley. The work is the first of its kind carried out in the National Tank and forms part of a general research on steering of ships. It is to be extended in the future to finer ships with twin screws, &c. The results obtained may be divided into two parts, the first dealing with "scale effect" or the application of model results to the full-size ship, the second touching such items as effect of shape of rudder, slip of propeller and wake of ship on the turning moment in the rudder stock and on the steering of the ship.

The difficulty in applying model data to ship was made very evident in Mr. Maurice Denny's paper last year. The forces on a given ship do not vary with the square of the speed, but to make model results fit the ship this law has to be assumed. The tank, by testing the same rudder made in three different sizes, have shown the cause of the trouble and the manner in which it can be properly dealt with. It appears from these tests that under *similar* conditions the rudder forces vary as the square of the speed, but if the speed of a ship is changed, the alteration in wave-making and surface disturbance at the rudder produces new conditions which are very dissimilar to those existing at other speeds, and it is wrong to expect a square law to hold in every case under such conditions. When the rudder is in its place behind the post of a ship, with a propeller working at normal slip, the authors found that, in the particular model tested, the surface effect is largely "washed out" by the propeller and wake effect, and the final formula given for rudder pressure is of the well-known type pressure $= k A V^2$, k varying with angle of helm, A being the rudder area. The constant will vary with fulness of ship as suggested in Mr. Foster King's paper, published in 1902—experiments to determine this variation are now being made.

A question which has been often discussed is the proper shape to give a rudder for good manœuvring power. The authors have tried rudders with area well to the bottom and to the surface, and with ship in deep condition have not been able to trace any noticeable effect either on rudder forces or steering of the ship, due to such changes. When the ship is in ballast trim, however, a rudder with more area at the bottom than at the top gave a larger turning moment on the ship, and the tests suggest therefore that ships which run in this condition might keep a little more rudder area near the keel and reduce it at the load level with advantage.

Perhaps the outstanding feature brought out in these tests is the important effect which results from the rudder working in both the ship's wake and the slip stream of the propeller. The model used was a fairly full one—having a prismatic coefficient of 0·78—and the twist on the rudder stock in the wake of this model, the propeller being idle, was only one-half that for the same rudder towed at the same speed without the ship model in front of it. But when the model is propelled by its screw, all this wake effect is annulled, and the twist on the rudder then exceeds the twist in open water at the same speed by 4 per cent. to 10 per cent. This difference in twist on the rudder is not due to any movement of the centre of pressure, but merely to increased pressure, and the effect of this increase is shown in the great difference in steering moment developed with and without the propeller working. In the former case the steering moment is 85 per cent. greater than it is with propeller idle, and this increase is reflected in the greater rate at which the model answered its helm when it was free to yaw, the model turning off its course 30 per cent. faster with the propeller working than without it—in the light condition the effect is somewhat greater presumably due to the increase in revolutions when the propeller "breaks surface." This propeller effect is a very considerable one, much greater than has been generally supposed. With such vessels the slip is fairly high—the true slip in this case was about 40 per cent., the apparent slip taken on the ship's speed about 5 per cent.—but this is always the case in single-screw ships. The authors propose to trace the variation of this effect with fulness of form, it being apparent that this should be done, if the results are to be used in design work.

It is the usual practice to determine the stresses on rudder stocks, &c., on consideration of normal conditions of propulsion, but it is equally well known that the abnormal conditions are liable to produce higher strains. Two such conditions have been tried by the authors, and work on a third is now proceeding in the tank. It has been found that when the ship is moving ahead, if the rudder is put over and the revolution of the screw is reversed the forces on rudder and ship are much smaller than for normal ahead motion the twist on the stock with 30 deg. of helm being less than one-half that for ahead motion when propelled by the screw. If the ship is moving stern first with revolutions of screw also reversed, the twist at any given speed is much greater than for ahead conditions. Whether the stern conditions are more severe than the ahead depends upon the speed a ship is likely to attain going astern. The authors show that with large helm, unless the astern speed exceeds about 80 per cent. the ahead speed, the ahead conditions produce the greater strain. Preparations are being made to obtain the twist on the rudder stock and movement of the ship model when the latter, having commenced to yaw under helm, the helm is suddenly reversed. Earlier work with balanced rudders has shown very high stresses due to this, and it remains to be seen how such a manœuvre may affect an unbalanced rudder.

A second research paper, equally complete in its treatment of the subject is being published by the tank staff at the spring meetings of the Institution of Naval Architects, and one hopeful and desirable feature in connection with the latter is the attempt being made, thanks to facilities provided by Sir Thomas Fisher, to check the work by full-scale

measurements. Similar treatment should follow the model experiments with rudders, and it is hoped that shipowners may see their way to assist the National Tank Committee and through them the industry in general, by assisting in such work.

RADIO-ACTIVITY.

On Saturday last, the 18th inst., at the Royal Institution, Sir Ernest Rutherford, F.R.S., delivered the third lecture of his course on the above subject.* In opening his lecture Professor Rutherford said that on the last occasion he had shown experiments to illustrate how we could study the chemical properties of the radio-active elements, although the quantity available was almost infinitesimal. This was possible because we could use the activity (as shown by the power to discharge an electroscope) as a means to estimate the amount present. He had thus shown that we could both dissolve and electrolyse the active deposits. By another experiment, which was of considerable importance in technical developments, when powerful sources of radio-activity were required, he proposed to show a method of isolating radium C from the active

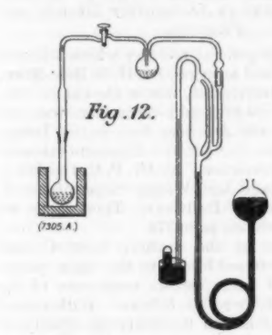


Fig. 12.

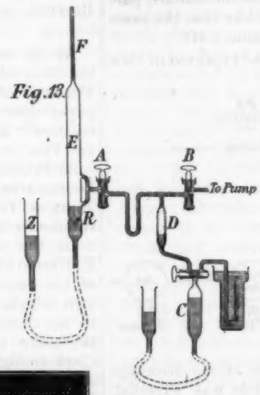


Fig. 13.

FIG. 14.

deposit obtained when a solid body was immersed in the emanation. This deposit consisted of Ra A, Ra B and Ra C. Radium A having a very short life rapidly disappeared, leaving behind the other two, of which radium C was by far the more powerful. If the deposit were made on a platinum plate or wire, a partial separation could be effected by heating the wire to 600 deg. or 700 deg. C. This operation distilled off most of the radium B, leaving radium C behind. Chemical methods were, however, much better. Radium C had one very interesting property. If a nickel plate were plunged into a solution containing both radium B and radium C, an electrochemical action occurred, with the result that the radium C was deposited on the nickel in a practically pure state. This radium C was, he said, emphatically the active constituent of the deposit, emitting very powerful β and γ rays. This the speaker illustrated by breaking up a tube which had contained radium emanation and dissolving off the active deposit by warm hydrochloric acid from which the radium C was separated out by a nickel plate as above described. The nickel plate in this instance, the speaker said, acquired an activity equivalent to about 10 milligrammes of radium, and it caused a Zn sulphide screen to phosphoresce brightly. The process was especially valuable in the case of the thorium family of radio-active elements. As shown in Fig. 3 which we published in our issue of March 10, page 300, a very active deposit was obtained from the meso-thorium chain, but as the life of the thorium emanation was so short, it was not possible to collect a large quantity of it. By dissolving, however, the active deposit in weak acid the thorium C could be separated out on a nickel plate as described above. About two-thirds of the total amount of ThC in the solution came down on the plate, and we could then easily get on it an activity equivalent to that of 30 milligrammes of radium; practically all of which was due to thorium C.

For general physical and chemical researches much use was made of the radium emanation, which was not only interesting in itself, but was of great importance in science and therapeutics. That the radium emanation could be condensed to a liquid had been shown by the Montreal experiments made by the speaker in conjunction with Soddy. They first found that, under the conditions of their experiments, it could not be condensed with solid CO_2 with which a temperature of -65 deg. C. was reached. They next got some liquid air and with this found that under the conditions in which they were working the emanation condensed at -150 deg. C. The lecturer showed that condensation did occur at liquid air temperatures by applying liquid air to different parts of a piece of apparatus in which emanation was imprisoned. Bright spots of phosphorescence appeared at the points of application, and it was shown that in this way the emanation could be distilled from one part of the apparatus to another, and different phosphorescent materials were made to light up in turn.

The fact that the emanation could be condensed was of great technical importance as it was employed to purify the gas. In general, tubes containing radium itself were little used either in laboratories or in hospitals, as it was found much better to work with the emanation. In the case of accident the loss of a radium tube would be a serious matter, but the loss of an emanation tube was trivial as the reserve of radium would grow the emanation again in the course of a few days. The apparatus used to charge the emanation tubes is represented in Fig. 12. The radium salt is dissolved in water contained in the bulb shown to the left, which, as indicated, is surrounded by a thick shield of lead. Emanation was emitted by the radium, and at the same time some of the water is decomposed by the active products formed. Some recombination occurs, but nevertheless the gases liberated consist of a little emanation mixed with a great deal of oxygen and hydrogen. The yield from 1 gramme of radium was about 20 cub. cm. of these mixed gases per day. When the emanation had to be collected the whole of these mixed gases was passed through the stopcock into the tubes shown to the right in Fig. 12, and most of the oxygen and hydrogen got rid of by sparking. The emanation was next condensed by liquid air and separated from the residual gases by raising the mercury bulb on the right, and finally the emanation was forced into the tube shown in the mercury bath near the bottom of the figure.

In the original experiments made in conjunction with Soddy the apparatus represented in Fig. 13 was employed. The condenser in this case was the U tube shown between the two stopcocks. The apparatus was exhausted by a mercury pump before starting operations, and the purified emanation was collected in the tube E, from which it could be forced up, for the purpose of measurement, into the capillary tube F. In their final experiments this tube was of so fine a bore that the correction for capillarity was 40 cm., and of this tube the gas they collected occupied, at a normal pressure and temperature, a length of about 1 in. They thus determined that the amount of emanation in equilibrium with 1 gramme of radium occupied 0·6 cub. mm. at standard temperature and pressure, *i.e.*, the volume was equivalent to that of a large pin head. Actually the amount used in the research was one-tenth of this amount, yet it was found possible to examine its properties almost as certainly as if 10 litres of it had been available.

They had, moreover, in the course of this research, determined practically all the lines in the spectrum of the emanation. This spectrum was represented in Fig. 14 sandwiched between two comparison spectra of helium. The emanation spectrum contained some 60 or more lines and was of a perfectly definite character. As already stated, they had found that under the conditions in which they were working, viz., at a pressure of about one-millionth of an atmosphere, the emanation condensed to a liquid at a temperature of about -150 deg. C. They had also determined its boiling-point at normal pressure, and found it to be about -70 deg. C. The emanation thus condensed formed a brilliant little point of light at the end of the capillary tube. At still lower temperatures it solidified. Further experiments, including some made by Ramsay using special methods, had definitely fixed the boiling point at -65 deg. C. The properties of the emanation were summarised in the following table:—

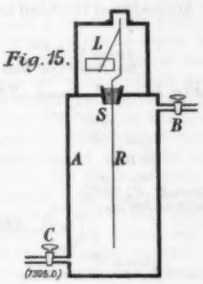


Fig. 15.

TABLE II.—*The Properties of Radium Emanation.*

Inert gas: Atomic weight = 222; atomic number 86.
Half transformed in 3·85 days: Emits α rays.
Volume at standard temperature and pressure in equilibrium with 1 gramme of radium = 0·6 cub. mm.
Strongly absorbed by charcoal, oils, fatty substances, and water.
Boiling point -65 deg. C.
Condensation point at low pressures = -150 deg. C.
Density of solid 5 to 6.
Orange red at liquid air temperature.

The emanation was the heaviest gas known and belonged to the helium and argon group. It was of great importance in the theory of atomic structure as being the gas of highest atomic weight.

Sir Ernest Rutherford next took up the question of the origin of radium and how its life period was determined. At the outset it had seemed probable that it was the direct offspring of uranium, but when Soddy tried to grow it from this element he could not for many years find a trace. It was clear, therefore, that some long period element intervened between uranium and radium, and, finally, Boltwood discovered ionium, which had the same properties as thorium, and could be separated from uranium by the same methods. Dissolving it out, Boltwood found that in the course of a few weeks radium had appeared in the solution. The principle of the method used was to seal up the solution in a glass tube, and after some weeks or months the gases were drawn off from the tube into an emanation electroscope which, as shown in Fig. 15, consisted of an ordinary gold leaf electroscope mounted above a chamber B, into which the gas could be drawn. With this instrument it was possible to detect the emanation even if the solution from which it was derived contained only 10^{-10} grammes of radium.

If the life period of one element in a chain of radio-active bodies was known, that of all the others could, Sir Ernest proceeded, be determined. Thus consider the chain which starting with uranium ended with polonium as the last radio-active member. Included in the chain were ionium and radium. Take, then, any uranium mineral in which, having existed for ages, all the members of the chain were in a state of equilibrium. Let us denote by N_1 the number of uranium atoms present, by N_2 the number of ionium atoms, by N_3 the number of radium atoms, and by N_4 the number of atoms of polonium. Then, as pointed out in the second lecture (see

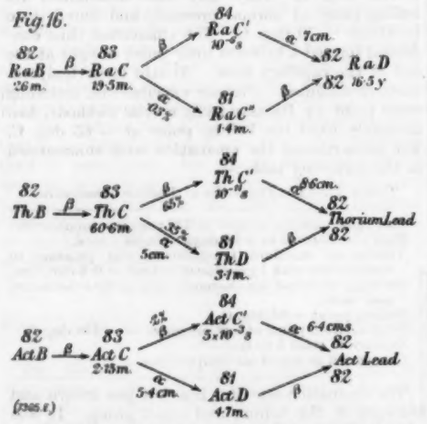
* Reports of the previous lectures of the course will be found in our issues of March 10 and March 17, on pages 299 and 331, respectively.

ENGINEERING of March 17, page 331), if λ_1, λ_2, λ_3, λ_4 denoted the corresponding radio-active constants, these constants represented in each case that fraction of the total number of atoms of an element, which exploded per second. Moreover, it was also shown in that lecture, that when the elements of a radio-active chain were in equilibrium with each other, the same number of atoms of each constituent were transformed in unit time. We thus got the relation

$$N_1 \lambda_1 = N_2 \lambda_2 = N_3 \lambda_3 = N_4 \lambda_4 \quad . \quad . \quad (4)$$

From this it followed that there would be very little of a short-lived member present in the mineral. Thus, suppose we separated out all the radium in the mineral, and measured its amount in terms of the activity of the emanation as expressed by the rate of falling in of the gold leaf of the electroscope, and having thus, by chemical means removed the radium from the mineral, a fresh supply immediately began to grow there, and by a fresh measurement the rate of growth was determined. As already stated the method was so sensitive that the emanation from 10^{-10} grammes of radium could be detected. By making a series of such determinations the value of λ for radium could be found. In the same time as new atoms of radium were formed in the parent numeral an equal number of atoms of the radium originally separated would be transformed into the emanation. Knowing the value of λ for

Fig. 16.

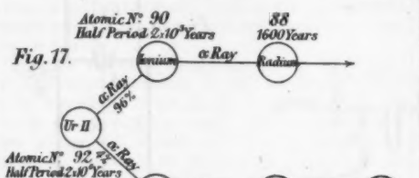


radium we could deduce that of the other bodies in the chain by means of equation (4) above. It was thus found that radium had a life period of 1,600 years, so that in 10,000 years 1 gramme of radium would have diminished to about 16 milligrammes. As stated in the first lecture the proportion of radium to uranium present in old minerals was 3·4 parts in 10,000,000. Hence N_3 the number of atoms of radium present was equal to $\frac{3 \cdot 6}{10^7}$. N_1, where N_1 denoted the number of atoms of Ur present. Thus the radio-active constant for uranium $\lambda_1 = \frac{1600 \times 10^7}{3 \cdot 6}$ so that a mass of uranium would diminish to half its original weight in some 5,000,000,000 years or so. If the rate of transformation had been much faster than this no uranium would now be left in the world. Similar methods were applicable to determining the life period of very short-lived products such as actinium A, which transformed to half value in $\frac{1}{100}$ second. The very wide range of instability in these elements was worthy of note.

There was at first sight a great similarity between the different radio-active families. All included an emanation which gave active deposits, but this similarity had little to do with the peculiar properties of these families, but was connected with Mendeleef periodic law. In all cases the C products showed extraordinary anomalies. Normally an explosion resulted in the emission of one α particle expelled at a definite speed, but there was evidence that RaC, thorium C and actinium C broke up in at least two and probably in three ways. At the time the explosion occurred the atom of a C product might, it appeared, be in one of two or three states of temporary equilibrium. Thus in the case of radium C we found as the result of the explosions a very small quantity of a body which broke up in 1·4 minutes and emitted β rays only. At the same time there was a much larger amount of a body produced which, in its turn, transformed with the emission of α rays. In the thorium chain (see Fig. 3, published in our issue of March 10, page 300) the distinction was much more marked, 65 per cent. of the one product being formed and 35 per cent. of the other. There was in this case a definite difference in the rays emitted, which implied a corresponding difference in the mode of explosion. The same held with actinium C. The explanation proposed of these anomalies was represented in Fig. 16, which, however, he might say was as yet somewhat speculative. It would be seen from this figure that if the transformation of RaC took place in one way β rays were emitted first; and this was followed by an emission of α rays from the product of the first transformation, the final product being RaD. This same final product was reached if the explosion took place in the alternative method, in which, in the first transformation, α rays were emitted, and in the second β rays. The scheme seemed to work very well for all three bodies represented in the figure, but Sir Ernest said he had recently found that when thorium C broke up, a third product was obtained forming one ten-thousandth part of the whole, and he was pretty clear that the same kind of thing occured with RaC and ActC.

Anomalies of this kind were to be expected in view

Fig. 17.



of the enormous disturbance of the atomic structure which occurred when an α particle was expelled. As this disturbance of the nucleus died down, it was not surprising if more than one stage of temporary equilibrium might be attained, so that certain atoms might subsequently explode in one way and others in another. The matter was of importance in connection with the origin of actinium. It was quite certain that this body was a branch to the main uranium-radium series, since if not so, the proportion of it present would be in disaccord with its life period. The actual amount present in the equilibrium condition was, in fact, only 4 per cent. as much as it should be were it a member of the main branch. The general scheme was represented in Fig. 17, from which it would be seen that UrII broke up in two ways, 96 per cent. went to form ionium and constituted the radium branch, whilst 4 per cent. went to form UrY which transformed into the recently-discovered proto-actinium and formed the actinium chain. The explanation above given fitted the facts, but recently Aston had shown that many of the elements recognised by chemists, and particularly the heavy elements, were mixtures of isotopes. It was very unlikely that radium was such a mixture, but uranium might be. In that case different atoms of uranium would differ in the structure of their nuclei, and thus one kind might be responsible for the ionium-radium chain and the other, existing in lesser quantity or slower in transforming, might be the ancestor of the actinium branch. It was believed, Professor Rutherford stated, that we now knew every member of the main branches of the radio-active elements, but new discoveries might be made in the side chains.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE BENEVOLENT FUND.

BEFORE the ordinary general meeting was commenced at the Institution of Mechanical Engineers, Storey's Gate, St. James' Park, on Friday last the 17th inst., the tenth general meeting of the Incorporated Benevolent Fund of the Institution was held. At this meeting the report of the Committee of Management, for 1921, was presented and considered, and the election of officers for the year 1922 was taken. The balance sheet shows the fund to stand now at 11,253*l.*, of which 11,001*l.* represents investments. The balance at the close of the previous year was 11,034*l.* The receipts of the year amounted to 1,220*l.*, including interest from investments, which amounted to 473*l.* The payments included grants to 13 applicants aggregating 973*l.* The total membership of the fund was 614 at the close of December, and in addition contributions had been received from 117 other members of the Institution. The total contributors thus appear to be only a little more than 700 out of a membership of about 8,000, so there is ample opportunity for improvement in the support accorded to this useful fund. In view of this fact it would seem to be rather unfortunate that, presumably by a misunderstanding, attendance of members of the Institution at this fund meeting was discouraged last Friday by admittance to the hall being denied to all except those who expressly stated at the door their desire to be present.

BRITISH AND AMERICAN LOCOMOTIVE DESIGN AND PRACTICE.

At the ordinary general meeting which followed the Benevolent Fund meeting, Dr. H. S. Hele-Shaw, President of the Institution, was in the chair. The paper down for reading and discussion was one entitled "British and American Locomotive Design and Practice: Some Comparative Comments thereon from Practical Experience," by Mr. P. C. Dewhurst, Locomotive Carriage and Wagon Superintendent, Jamaica Government Railways. This paper we commence to reprint on page 373.

In the absence of the author, Lieut.-Colonel E. Kitson Clark referred briefly to the main points of the paper and made certain comments of his own which, shortly, were as follows. With regard to the question of lateral flexibility or rigidity of the plate frames and bar frames, Lieut.-Colonel Clark thought the plate frame as made in England was a box girder of an exceptionally rigid type. In American practice, the bar frame represented two separate units fixed together, and the width of the bar frame, in each case, was supposed to give sufficient lateral rigidity to prevent the engine coming to grief. The bar frame and the plate frame were rigid or the reverse according as they were tied diagonally or straight across. With regard to tank engines, it appeared to him that there were many duties required from locomotives which would point to the use of tank engines, and it would be interesting to know why these engines were not more largely employed in America.

The author referred to the simple method of tying the bottom of the horns together by means of bolts and cast iron distance pieces. The straight bolt and distance piece held the bottom of the horns together in a definite practical manner. On the question of fire boxes, he (Colonel Clark) thought locomotive engineers were influenced by fashion. When the Belpaire box was introduced there was no room above the fire-box for the steam to get away from the water, and with bad water the crown stays going over the fire-box became coated with deposit, with danger to the life of the fire-box and to that of the boiler. To avoid using stays which passed diagonally through a plate, a flat top fire-box was necessary, which gave a large space for the steam. Round top fire-boxes were, however, far cheaper to make, and it might be worth while now re-considering the methods of constructing round top fire-boxes. With regard to fusible plugs, the author's remarks were interesting, particularly the point that, in one case, too much tinning had been done before the white metal had been put in. His own experience had been the reverse of that.

Sir Henry Fowler, K.B.E., remarked that two of the points raised by the author related to questions which always beset the designer in this country, namely, the loading gauge and the weight on the bridges. In America these considerations were nothing like so important. Dealing with bridges, it was a question of capitalising the money that would be saved by using larger locomotives. In America it was possible to travel 200 or 300 miles

without going over, perhaps, more than a dozen bridges over streams—practically never a bridge over a road. In this country the trains were constantly running over bridges. Mr. Dewhurst had laid emphasis on the ten-coupled engines. Only one such engine was running on the main line of the Midland Company, and in a distance of 1½ miles four bridges were crossed. Although it might be said that it was easy to re-build such bridges, it had been possible to construct a locomotive which rendered that expense unnecessary. With regard to wagons, also, the capital value of making alterations would be found to involve a large sum. He had always been glad that Stephenson had put a crown, or ragged piece of tin work, on the top of the "Rocket," as that circumstance was responsible for an additional foot of head room to-day in every existing tunnel. In connection with outside cylinders, in the majority of the Colonial countries there were no platforms, and there was no question of coming within the gauge, as in this country. On the subject of the larger boiler, the best way to burn coal was to burn it slowly, not intensely, with a blast that carried a large proportion of the fuel, under certain conditions, through the tubes into the smoke-box; there, again, the question of weight allowed came in. There was no better way of using steam in a locomotive than in a compound which was superheated. He did not consider that there was any question as to using acid steel or basic steel, other than the question of how the basic steel was made. They had flanged axle box splashers 16 in. deep out of basic plates 45 in. long without difficulty. The plate was not thick, of course.

With regard to the use of copper and steel in fire-boxes and tubes, he could only say that he did not wish to see any more steel boxes in use on his company's line; the whole of the lower portion of the several steel boxes he had inspected that day were far worse than they would have been had they been made of copper. His company had used a large number of steel tubes during the war, but had replaced them as soon as possible, owing to the numerous casualties arising from leaky tubes. He had been much interested in the author's remarks about the fusible plugs. The Americans regarded that subject as of sufficient importance to get the Bureau of Standards to make investigations. It was not the universal opinion in this country that the fusible plug was the right thing; it required to be properly made and looked after. A large number of difficulties would probably disappear if the tube were filled with lead, allowed to cool and then melted down again, as this would remove the trouble due to excess of tinning. For the locomotives on his company's line, it had been found advantageous to use for the connection between the superheater tube and header a copper ring of diamond section, set in grooves both in the header and in the ring surrounding the superheater tube. With regard to the practice of securing tyres by shrinkage, the Midland Railway used a shrinkage allowance of $\frac{1}{1,100}$ of the diameter as against $\frac{1}{750}$ mentioned by the author. The allowance depended largely upon the finish; with a rough finished tyre a greater shrinkage was needed to get a grip than when there was a true finish. Several years ago the system of lubrication in which waste and horse hair were used had been given an extensive trial on the Midland Railway, but great difficulty arose owing to the tendency of the horse hair to get into the oil channels and curl up into small balls. With regard to the author's figures for oil consumption, he would say that on the Midland Railway, using mechanical lubricators on the axle boxes, the consumption had been reduced to 66 per cent. of the figure stated by Mr. Dewhurst.

Mr. R. P. C. Sanderson, of the Baldwin Locomotive Works, remarked that while it was obvious that Mr. Dewhurst was speaking from personal knowledge, his experience was not altogether up-to-date. It was no longer an American practice to build locomotives for stock or to stock patterns. Just as in this country, the mechanical engineers of the American railways designed their own locomotives and supplied the builders with drawings and standards to work to. Sometimes, when a new design was to be worked to, the chief mechanical engineer would come to the works and make use of the works drawing office to get out the design. It was up to the mechanical officials of the American railways to see that their own standards and the Master Mechanics' standards—which it was imperative should be used—were embodied in the designs. American designers did not now use flangeless wheels except for shunting engines of the 0-6-0 type in yards or the 2-10-2 type heavy locomotives where the centre axle was equipped with bald tyres; otherwise, the six-coupled and eight-coupled engines of all types in general railway service were equipped with all flanged tyres, the front and back being usually set in a little, so as to add to the freedom on a curve, instead of thinning. The three and four-cylinder engines had, in America, largely gone out of use. It was found more economical to maintain the two-cylinder engine than to keep up the multiple-cylinder type.

It was true that in America they did not employ tank engines to the extent they were used in this country, and for this there were sound reasons. Even in the shunting service, the loads were very much heavier in the States than they were here. When it was necessary to bring trains weighing from 3,000 to 7,000 tons into a yard and break them up, a great deal of power had to be exerted. A tank engine could not be built to carry enough water to go through a whole shift without running two or three times to the column for water; such an engine would not be able to keep to schedule. In America shunting engines were designed to carry in the tender enough water for the shift. In the suburban service also the need was for more water than the tank engine could carry; otherwise the tank engine would be welcomed in certain services. On the question of inside and outside cylinders, he had not seen mentioned anywhere the fact that a long engine could not be made to nose; with a long engine nosing would be out of the question, because its length was too great to allow it to swing in synchronism with the speed of revolutions of the engine. American practice was to make cylinders with separate liners—or bushings, as they were called there. The liner was usually of a hard white iron, a different iron mixture from that for the cylinders. Thus a hard wearing surface was obtained and a tough steam tight iron for the bodies of the cylinders. Nearly all the engines now built were piston valve engines, and the piston valve bushes were also made of white iron; there was the additional advantage that they could readily be renewed.

The rigidity of the bar frame lay not only in the section of the frame itself, but in the fact that the two bar frames were braced together quite as rigidly and formed as stiff a unit as could be found in any combination of plate frame and gusset bracing used in this country. In designing it was essential to provide for flexibility separately and distinctly from any yielding or flexure of the frames; otherwise fractures and breakdowns were almost unavoidable. With regard to pedestal braces or hornstays, the bolt and cast iron thimble between the bottom ends of the horn had been largely abandoned on account of the stretching of bolts. The bottom of the horns projected slightly with a taper fit, the horn stays fitting up on either side of the taper projections at the bottom of the bar frame. As the frames were, in modern engines, anything from 4½ in. to 6 in. wide and the projection might be 1½ in. deep, there were a good many square inches of bearing surface on both sides of each projection below the horns.

The trailer truck type of engine had grown into very great favour in America latterly. This was altogether a question of boiler limitation. In America they had been compelled to build boilers of greater capacity to get full use out of the chassis under the boiler, and to get economic combustion. However satisfactory the clearance dimensions, a boiler could not be designed to give the full economic supply required for the adhesive weight unless part of the load were carried on a trailer or carrying axle. For this reason the 4-0-0 engine had become the 4-2-2, the 4-6-0 the 4-6-2, and so on. With regard to the vertical faces of the axle boxes and the horns, with the modern engines the frame might be as much as 6 in. wide, and, since the shoe and wedge had flanges as thick as 1 in., there would be a bearing between the axle box and the horns of practically 8 in. In this connection he might mention that many railways used cast iron shoes and wedges lined with brass, the brass and iron being poured into the same mould and united. With regard to the wearing surface between the wheel hubs and the boxes, American practice was to use a renewable liner on the hub of the wheel and not on the box. These liners were, however, frequently put on the box after the latter was badly worn. It was, further, a common practice to make boxes lopsided—half or three-eighths of an inch longer one way, and when the wear had become excessive the box was turned round.

In concluding, Mr. Sanderson, at the request of the President, promised to communicate some further remarks in writing.

Captain H. P. M. Beames, of the London and North-Western Railway, said the author had stated that the removable shoe system allowed the lining up and re-centreing of a whole set of wheels and axle-boxes. He was not inclined to regard this as an unmixed advantage; in the hands of inexperienced men it was conceivable that the centres of the wheels might be pulled to such an extent as to cause considerable trouble both with the boxes and bushes of the side rods, and also from loose and broken crankpins. The late Mr. Webb had proved that the centres of the horns on an engine that had been in traffic for some time extended; on a six-coupled engine, the extension had been found to be as much as $\frac{1}{8}$ in. Mr. Webb, for this reason, had always added a suitable length to the centres of the side rods, making these slightly longer than the original length on the drawing; the results were excellent, and some of the engines were running to-day. On the London and North-Western Railway, axles without any collars on the journals had given good results. Had the author had any experience of the Nicholson thermic syphon system? He had tried one on a large passenger main line locomotive, but did not meet with the success anticipated.

On the subject of safety valves, he would be glad if the author could give American figures for clearances allowed between the wings of the valves and the seat, and the angle of the seating. He had recently carried out tests with a Webb-Ramsbottom safety valve thoroughly warmed through, the outside temperature being that of the shop in which the test was made, and found that with a clearance of $\frac{4}{1,000}$ of an inch there was slight sticking; with $\frac{5}{1,000}$ clearance there was binding; and with $\frac{6}{1,000}$ clearance complete freedom. When the same valve was surrounded by a bath of water the results were as follows. With $\frac{6}{1,000}$ in. clearance (measured with the valve and bush both cold) there was sticking, and with $\frac{8}{1,000}$ in. complete freedom. In water cooled down by the addition of ice complete freedom was obtained with a clearance of 9·5/1000 in. A further test was made with cold air blowing at about 32 miles an hour, the temperature being about 8½ deg. of frost. In this experiment the valve was quite free with a clearance of $\frac{8}{1,000}$ in., or less than that required with ice cold water. Curiously enough, the bush was found to be $\frac{2}{1,000}$ in. smaller after these experiments, due doubtless to the drastic treatment of the valve. His company had tried the Franklin type of grease lubrication for axle-boxes, but he was compelled to admit that nothing could beat good oil suitably applied and consistently fed. Worsted trimming would only syphon oil in proportion to the height of lift. For main-line engines the box must be so designed that at the finish of the run the oil syphoned would be the maximum required. The London and North-Western Company had also tried horse hair and waste, but without success.

Mr. J. A. Hookham, of the North Staffordshire Railway, agreed in thinking that the author's

experience was scarcely up-to-date, with regard to British practice. The round-topped axle-box was not peculiar to America; it was used on the North-Western Railway, and a side surface of white metal was put on in place of the brass liner, to give a broad bearing surface. Steel tubes were very largely used in this country; he would think that more steel tubes were put into locomotives than brass or copper. The inability to use steel fire-boxes here indicated, he thought, that boilers on the other side were less hard pressed than ours, and the boiler capacity was very much greater. He was in sympathy with the American neglect of fusible plugs; it was often difficult to say whether the fireman or the plug was at fault when trouble arose. He felt that expanded tubes in the superheater were exceedingly tiresome things, as, when repairing a superheater, such tubes took much longer to pull out than a bolted tube would take. With regard to the elimination of dampers, he would say that his own company had long dispensed with them and had found no difficulty as a consequence. The author has also mentioned the admission of air to the header when drifting, and seemed to expect lubricating difficulties; he agreed, as carbonising would probably eventuate, there being no particular reason why the oil should not actually burn.

He was in favour of the saddle type of smoke-box. He considered that on the engines on his line an improvement had been affected by caulking round the steam and exhaust flanges with lead; this did not melt, and a good smoke-box resulted. With American safety valve practice he fully agreed. Mr. Pickersgill had proved that 30 lbs. additional pressure were required to secure the necessary opening, with the Ramsbottom valve, to let the steam out when the boiler was fully fired. On the North Stafford Railway the "Ross" safety valve was used, and with this valve the opening and closing pressure margin was 1½ lbs., as compared with the 3 lb. mentioned by the author. The long piston rod on American locomotives was, he considered, an excellent idea, if room allowed it to be used. He was unable to see any object in making the side rods with but little lateral stiffness; there was no advantage in allowing the rod to buckle. With regard to the weakening of the tyres at the holes of the set-screw fastening, he questioned whether the tyres needed fastening at all. Not many years ago it had been the practice to drive keys into the idle axles. That was really not necessary even in the case of the driving axles. So long as it was not worn too thin the tyre would not come off inside, because of the lip, or outside, because of the flange. A central buffer and coupling combined would be an excellent thing, but expensive to introduce; the coupling should be capable of screwing up, just as with the ordinary coupling used in this country.

The President then proposed, and the meeting agreed, that the further discussion of the paper be adjourned until the 24th inst. (to-day).

Lieut.-Colonel Kitson Clark stated that he would report to the author the great interest which his paper had evoked. The stretching of bolts in pedestal braces or hornstays was a matter of great interest in the railway world, and the time was coming when it would be necessary to consider of what steel bolts should be made. For instance, in fastening cylinders to frames the workman was in the habit of tightening them up very tight and was thus likely to draw them thin, with the result that they were a loose fit. Sir Henry Fowler had referred to the flanging of a basic steel plate of ⅞ in. thickness. Flanging a thick plate, however, was a different proposition.

With regard to the use of tank engines for shunting, in that work it was desirable to have the whole adhesive weight during the whole of the time, and this was one of the disabilities of the tank engine, however convenient in other respects, because of the loss in coal and water. With regard to safety valves if a three-winged valve and a four-winged valve were turned with exactly the same tolerance between the valve and valve seat, the three-winged valve would have greater freedom than the four-winged valve. When heating up took place, the three-winged valve would jam just as easily as a four-winged valve. It was a point for consideration whether the valves should be three-winged or four-winged.

The President then announced that on the 31st inst. a meeting would be held at which a paper would be read by Dr. Jeffcott—the new Secretary of the Institution of Civil Engineers—on "The Milling of Screws and other Problems in the Theory of Screw Threads." The proceedings were then closed, the discussion of Mr. Dewhurst's paper being, as already mentioned, adjourned until to-day.

MAGNETISM AND THE ETHER.

THE words by which Sir Oliver Lodge approached the subject of his Silvanus Thompson Memorial Lecture on "Magnetism and the Ether," on Tuesday last, before the Röntgen Society, was somewhat startling for the locality, the lecture hall of the Institution of Electrical Engineers. "You can generate heat, light and sound; you cannot generate magnetism, electricity or matter." Nobody expected to generate matter, he continued. People had thought they could generate electricity; we knew now that we could only set it in motion. People still believed that they generated magnetism; they certainly made magnets, but always with the aid of an initial magnet. So we could generate oaks and chickens; but there was no life without antecedent life. The germ of life had to be present, showing that life was not a form of energy that could be converted into another form; life must have pre-existed and brought into interaction with matter. So also with magnetism; it was always passed on. The energy belonging to it had to be supplied by the arrangement which had apparently produced it. In the case of life the energy was supplied by food, in magnetism by the muscular or other action which withdrew the magnet from the generating field.

It might be objected that the electromagnet anyhow was generated by an electric current. Sir Oliver admitted that an electric current could be generated by setting an electron in motion; but the magnetism accompanying the current was something pre-existent in the ether. Heat, light and sound were forms of energy; magnetism was no more a form of energy than was electricity or life. The art of magnetising a piece of iron consisted in opening out the molecular magnetic loops of force already there. Those lines enveloped a large area; as the magnetism was destroyed, the lines shrank, but they remained closed, ready to swell out again on re-excitation. Matter was not necessary for the magnetic field. We could magnetise a vacuum. Magnetic substances had a large number of such loops in their own constitution, existing independently of their matter. But the extra loops were not essential; sufficiently strong currents might produce equally strong fields in empty space, that is, in the ether. The field surrounding the equator of an electron moving at 1/30 the speed of light, was prodigious, 10^{15} c.g.s. units; as we approached the velocity of light a limit of field intensity seemed to be reached, so that it became impossible to make an electron move at more than the speed of light. But 1 mm. away from the electron the force was next to nothing.

An electric current was likewise continuous and circuital. When the electric lines of force were cut, however, the portion inside the conductor ceased to be, and the residual lines of electric strain stretched only from one conductor to another through the intervening insulating region, their terminations being known as electric charges. Those charges we could separate and neutralise. But we could not cut the magnetic circuits, nor separate the poles. Electric and magnetic loops were always interlinked. As the current strengthened, or weakened, the magnetic loops expanded or contracted; when the generating current ceased, the loops enclosed an infinitesimal area, but the Amperian currents remained.

If, then, the magnetic circuit always remained closed, there was the possibility that something was circulating round it. The theory of Sir Joseph Larmor and others, which had some kinship with the vortex theory, postulated that it was probably the ether which was circulating. Though absolutely stationary as regard locomotion, the ether might be capable to spin in closed circuits, and many facts in light, electricity and magnetism indicated that this hypothetical circulation had some foundation in reality. The electric properties of the ether suggested something akin to elasticity, the magnetic properties something akin to inertia. The interaction of these two properties rendered possible wave propagation, which could not occur except for those two properties. These fundamental properties, at present unknown, were designated k electro-inductivity or dielectric constant, and μ magnetic permeability. Maxwell showed that the reciprocal of their geometric mean was the velocity of light: $v = 1/\sqrt{k\,\mu}$. For a science of the ether of space we needed to know more than that product. Relativity did not deny the ether; certainly neither Einstein nor Eddington did. On the contrary, Einstein had strengthened the position of the ether by linking gravitation with it. In the electrostatic system we made k a unit (of unknown dimensions); in the electromagnetic system μ was a unit. But that was not legitimate. Neither property belonged to matter; they were properties of ether, and our experimental k was really the ratio k/k_0, where the k_0 of the ether was unknown. Every physicist should bear in mind the fundamental importance of the separate determinations of k and μ, or at any rate of their ratio or some function.

The working hypothesis on which Sir Oliver Lodge had proceeded in his own attempts to determine the nature and magnitude of k or μ was that there was a slow etherial circulation or flow along the lines of a magnetic field, a flow which could not be excited or stopped, but be opened out so as to be made perceptible. Sir Joseph Larmor had asked him in 1893 whether transmission along lines of magnetic force in air appreciably altered the velocity of light; if magnetic force were velocity of the ether, he (Larmor) could correlate many things. Sir Oliver had then been engaged on such experiments at Liverpool, and had recently resumed the theoretical study of the problem. The circulation, he explained, would naturally be slow on account of the enormous density of the ether. We could determine the strength of the experimental magnetic field; if we know the ether density we could deduce the rate of flow, and if we could measure the rate, we could deduce the density of the ether or of whatever it was that was flowing.

The experiments were arranged somewhat on the lines of the famous Michelson-Morley experiments for detecting any ether drift, on which Sir Oliver also experimented. A frame of wood, 1 metre square, was set up. Inside the vertical walls of the frame three mirrors and a half-silvered glass were so fixed symmetrically that a beam of light falling on the glass was sent round the frame several times in quadrangular paths. The ray transmitted through the glass travelled one way, the reflected ray the other way round, each describing a quadrangle inscribed in the square frame. Thus there were always two rays of opposite directions close to one another, and the two rays issuing would interfere so that the observer saw a set of bands, which should shift if the rays were accelerated or retarded by some force, *e.g.*, a magnetic field. In order to create this field, Sir Oliver mounted four solenoids in such a way in the frame that each pair of rays travelled axially through one after the other of the four hollow cores of the solenoids. The solenoids consisted of tubes, doubly walled, to circulate water through the jacket, elliptical in section, each 44 cm. long and wound with 22 layers of $N\alpha = 18$ wire, capable of producing a field of 1,400 c.g.s. units. The solenoid cores were charged with air, water or carbon disulphide, the open ends of the tubes being in the latter cases closed by optically-plane glass plates; the carbon disulphide proved very troublesome, because it is highly refracting, and the slightest heating (in spite of all cooling) distorted the bands. But no shift was ever observed with 120 or 230 volts in the circuit and switching the current on or off or reversing it, while a shift of 1/100 of a band width could have been detected. The light was sometimes sent round the frame four times so that the actual path length was 14 m.

Later considerations convinced Sir Oliver that the experiment was almost, though not quite,

hopeless. He had assumed an ether density eight times greater than that of platinum. [To understand what that means we must remember that the actual space occupied by the platinum molecules is only 10^{-10} of the apparent volume of the metal.] With such a density the expected ether motion would be at the rate of a few inches per hour, a mere snail's crawl. Sir Oliver might, with his arrangement, have detected a flow of 1 ft. per second. But there were reasons to belive in an ether density of 10^{12}, and with a frame of 10 m. (instead of 1 m.) and solenoid bobbins with 1,000 turns per centimeter, cooled by liquid helium, an effective flow of 3 mm. per second might be observed, if such experiments could be carried out.

It would be well worth trying, Sir Oliver remarked in concluding. If all the experiments failed, there would be something wrong about ether theories. Success would bring the first experimental verification of the theory of ether wave-propagation. That would help us to understand radiation, emission, absorption and refraction, and give some clue as to the prodigious energy stored in the ether—vastly superior to the atomic energy as distinct from the molecular energy, which we were already tapping possibly in the solar heat.

NOTES.

THE MOTOR TANK SHIP "NARRAGANSETT."

AN opportunity was given to the members of the Institution of Automobile Engineers on Monday last of inspecting the machinery of the motor tank ship Narragansett, which was then discharging part of her cargo at Purfleet. The vessel, it will be remembered, is owned by the Anglo-American Oil Company, Limited, and has now been running for nearly two years in the North Atlantic trade carrying motor spirit and other petroleum products in bulk between New York and other American ports and the company's depots on the Thames. She was built by Messrs. Vickers, Limited, at Barrow-in-Furness and fitted with two sets of Vickers' solid-injection oil engines, each developing 1,250 b.h.p. We have, however, already illustrated and described the vessel and her engines on pages 623 and 716, vol. cix of ENGINEERING, so that we now need only refer briefly to the results obtained on service. These Mr. F. E. Powell, the Chairman of the Anglo-American Oil Company, said, had been entirely satisfactory, the only repairs necessary during the period being of a very minor character and such as would be required in any type of ship. He rightly attributed this partly to the skill of the men in charge of the machinery and partly to that of the designers and constructors. Sir James McKechnie, who was present on the occasion, mentioned that the vessel had now covered 95,000 miles at an average speed of 10·5 knots and the fuel consumption was from 9¼ tons to 10 tons a day when carrying 10,000 tons of oil as cargo. He regarded this as a record of which all connected with the vessel might well be proud. In conclusion, Sir James remarked that the builders and owners had been in collaboration since the maiden voyage of the vessel and as a consequence of this he thought that the excellent results already achieved would be brought still nearer to perfection in the future.

THE FUEL PROBLEM.

A lecture on the Fuel Problem was delivered on the 14th inst., by Dr. C. H. Lander, before the South Wales Branch of the Institution of Mechanical Engineers, at Swansea. Dr. Lander's position as Assistant to the Director of the Fuel Research Department, Scientific Industrial Research, naturally furnished him with a good deal of first-hand information on this subject. After discussing the constitution of coal and the results of recent microscopic research Dr. Lander passed to the question of a survey of our coal supplies from the physical and chemical points of view, with the idea of the better utilisation of the coal in the most suitable manner. It has been decided for this purpose to set up local committees in mining centres in close connection with a central authority, and with the Geological Survey. Through these committees samples will be obtained and analysed, with a view to putting the coal to the most suitable commercial use. The first committee is now at work in the Lancashire and Cheshire district. Passing to the methods of using coal, high temperature carbonisation was next considered, and the effect of recent changes in legislation affecting gas supply, was discussed. The complete gasification of coal, and steaming in vertical retorts were also considered, Dr. Lander stating that the Research Board had now begun an investigation of a well-known Lanarkshire coal. In all coals tested at the Research Station an increased yield of therms in the gas has been obtained at a decreased expenditure of heat, when using 5 per cent. steam, as compared with the yield without the use of steam. In connection with low temperature methods, the Research Board had been working with horizontal steel retorts heated by water gas, the best results having been obtained with a mixture of dry and fusible coals in equal proportions. From the Carbocoal and Barnsley processes previously described in our columns, and other systems using external heat, Dr. Lander passed to systems using internally applied heat such as the Nielsen system described elsewhere in this issue. The concluding part of the lecture was devoted to steam raising, pulverised fuel and domestic heating. In connection with pulverised fuel the success attained with this, in cement kilns was cited, while with regard to domestic heating a word was put in for the open hearth, which made available either directly or otherwise all the heat except that which escaped in the rejected products of combustion. Directly radiated heat amounted to 25 per cent. of the heat of the coal, but some of the modern well grates were deficient in radiating qualities.

INSTITUTION OF NAVAL ARCHITECTS.

The secretary, Mr. R. W. Dana, has succeeded, notwithstanding the difficulties of the times, in preparing a varied programme for the forthcoming annual session of the Institution, which is to be held in the Lecture Hall of the Royal United Service Institution, Whitehall, on Wednesday, Thursday and Friday, April 5, 6 and 7. There will be a reception in the Naval Museum of the R.U.S. Institution on Tuesday evening, and the annual dinner of the Institution of Naval Architects will be held at the Connaught Rooms on Wednesday evening. The business proceedings will begin at 11 o'clock on Wednesday, when the president, the Duke of Northumberland, will give an inaugural address. This will be followed by a paper on "Merchant Shipping and World Commerce in Relation to Sea Power," by Sir Westcott Abell. This is in accordance with the traditional practice of the Institution, as the admirals usually have a field day in connection with the opening paper. Sir Westcott Abell is quite capable of "drawing" them, and it will be interesting to know their feeling in view of the Washington Conference and the Geddes cuts. Mr. J. H. Narbeth, who was associated with the design of the Dreadnought, is to read a paper on "Three Steps in Naval Construction—King Edward VII—Lord Nelson—Dreadnought." We presume it will be largely historical. At the afternoon meeting on Wednesday, the subject of the "Resistance of Ships among Waves" is to be dealt with by Mr. J. L. Kent, one of the staff at the National Physical Laboratory Tank. Importance attaches to the first two papers to be read at the Thursday meeting, which opens at 11 a.m., as they deal with the question of gearing, with which there has been considerable trouble in ships at sea, and we hope that there will be a frank disclosure of the difficulties which have arisen, because the diagnosis of a malady is an essential preliminary to its cure. Dr. J. H. Smith is to read one of the papers, which is on "Nodal Arrangements of Geared Drives," and Mr. J. Wilkie will read a paper on "Double Reduction Gears in the SS. Melmore Head." The third paper at the morning meeting on Thursday is by Mr. T. C. Tobin, and is on "A Method of Determining the Natural Periods of Vibration of Ships." At the afternoon meeting on that day Mr. John Reid will contribute a paper on "The Possibilities of Fuel Economy in Marine Boilers," and Mr. J. L. Hodgson one on "The Metering of Steam." Usually, the evening meeting on Thursday is given up to an engineering subject of topical interest, and there is every prospect of an informing discussion on a paper to be read by Mr. James Richardson, B.Sc., on "Diesel Machinery for Single-Screw Motor Ships." Friday will be the shipbuilders' day, and at the morning meeting Mr. E. L. Champness will read a paper on the "Longitudinal Strength of Cargo Vessels and its Variation with Fullness of Form." The remaining papers are on "Some Special Cases of Two-Dimensional Stress or Strain," by Professor C. E. Inglis; and "The Economic Efficiency of Merchant Ships," by John Tutin; and, in the afternoon, at 3 p.m., Mr. J. Rennie Barnett will read a paper on "Recent Developments in Motor Lifeboats."

MOTOR CAR SPRINGS.

In a paper on motor car springs, read on the 8th inst. before the Institution of Automobile Engineers, Mr. A. A. Remington discussed the principles involved in their design. In order that the passengers should not leave the seat it was, he said, necessary that the accelerations due to the external forces acting on the vehicle should not be greater than that due to gravity. The accelerations experienced by the body of the vehicle depended on the periodicity and amplitude of the suspension, and on the magnitude of the external forces. The latter, being due to the inequalities of the road, were beyond the control of the designer, but in practice it was found that excessive shocks would seldom be experienced if the springs had a periodicity of 90 complete oscillations per minute and a static deflection under that load of 4·4 in. Lower periodicities would give still smoother running, provided that difficulties did not arise in respect to mudguard and road clearances. Very low rates of oscillation were, however, found to lessen the adhesion of the wheel to the road and give rise to slip. In a chassis weighing 20 cwt. to 24 cwt. the weight of the suspension would frequently be as much as 200 lb. Autographic records taken on the road showed that in the case of the rear wheels it was necessary to provide for deflections equal to one and three-quarters to twice the static deflection, the corresponding figure for the front springs being 2½ to 3. The front springs being the stiffer, the maximum deflection was, however, generally less than that of the rear wheels. For carbon steel front springs the working stress under static load should not exceed 20 tons per square inch, or 30 tons per square inch in the case of the rear springs. With alloy steel these limits might be 20 per cent. more. In automobile practice the initial camber was such that under its designed static load the spring was practically flat. The periodicity P of the spring expressed in complete oscillations per minute could be calculated from the formula

$$P^2 = \frac{35,230}{d}$$

where d was the static deflection in inches. The value of d could be found from the formula

$$d = \frac{W\,l^3}{4\,b\,.\,E\,n\,t^3}$$

Here W denoted the designed load in pounds, l the length of the spring in inches, b its breadth, n the number of leaves and t their thickness in inches. To allow for certain approximations made in deducing this formula it was usual to take E as 22,500,000 lb. per square inch, instead of the normal value for steel.

THE AIR ESTIMATES.

In accordance with the urgent need for economy in national expenditure the Air Estimates for the year 1922–23 have been reduced by over 7,500,000*l.*, in comparison with those for the current year. The estimated expenditure in the ensuing year will be 10,895,000*l.* the most important items being pay, 3,781,000*l.*; quartering, stores, supplies and transport, 1,530,000*l.*; technical and warlike stores, 1,295,000*l.*; works, buildings and lands, 1,826,000*l.*; and experimental and research services, 1,177,000*l.* All these items show a material reduction, the previous figures being 4,804,010*l.*, 3,105,000*l.*, 3,758,000*l.*, 3,018,000*l.* and 1,706,000*l.*, respectively. Of the total figure given above 9,935,500*l.* is for normal services and 959,500*l.* for war liabilities, the corresponding figures from the original estimates for 1921–22 being 15,809,000*l.* and 1,471,000*l.* and totalling 17,280,000*l.*, together. There is thus a reduction of about 6,400,000*l.* or 37 per cent., 20 per cent. reduction being in accordance

with the directions given by the Government to all departments, and the remainder being partly due to the suggestions of the Geddes Committee and partly to independent action by the Air Ministry. The active strength of the Air Force will be reduced by the equivalent of two squadrons, and the equivalent of three more squadrons will be withdrawn from co-operation with the Navy and Army and allocated primarily to home defence. These squadrons will, however, still be available for co-operation work on special occasions and will also be used for training purposes. In his memorandum accompanying the Estimates, the Secretary of State for Air remarks that expenditure on works services has been cut down to a minimum and stocks of machines, engines and spares will be drawn on without replacement wherever possible. He points out, however, that this procedure is essentially a process of deferment of expenditure which will tend to increase the votes in future years. The vote in connection with civil aviation amounts to 364,000*l.*, as compared with 880,000*l.* in the current year, but the approved scheme for subsidies for cross-Channel flights, which comes into full operation on the 1st prox., remains unaffected. The cost of the subsidies is estimated at 200,000*l.*, and a sum of 80,000*l.* is required for meteorological work. On the experimental and research services the reduction amounts to 529,000*l.*, the most important reductions being 140,000*l.* in connection with the Royal Airship Works, Cardington, and 141,000*l.* in connection with the liquidation of war liabilities. The total reduction of this vote is appreciably less than that recommended by the Geddes Committee, but the Air Ministry point out that had those recommendations been accepted in full, nothing would have been left for the development of new ideas during the coming year. We agree that this would be very undesirable, and we think that the decision to make provision for placing experimental orders on a very restricted scale will meet with general approval, since, while it is certainly essential to curtail present expenditure by every possible means, it is equally important that future progress should not be unduly impeded.

THE RELIABILITY OF LARGE GAS ENGINES.

TO THE EDITOR OF ENGINEERING.

SIR,—Your issue of March 10 contains an exceedingly valuable article by Professor W. T. David, M.A., D.Sc., on "Some Properties of the Working Fluid of Gas Engines." It is unfortunate, however, that the article contains a phrase which is apt to give rise to an erroneous impression—I refer to the phrase "unreliability of the large gas engine" which appears twice in the article. Professor David shows that with increase of cylinder dimensions, the loss of heat by radiation per unit area of wall surface increases, the conditions of mixture strength and speed being unchanged. This is incontestable and the difficulty in obtaining effective cooling water circulation in the jackets of large gas engines is a very real one.

Nevertheless, it is incorrect to characterise the large gas engine as "unreliable," by which is usually understood "liable to breakdown." The effect of dimensions on heat loss imposes limitations, *e.g.*, prohibits the adoption of high mean effective pressures, but as constructed and rated, and, as is amply verified by the experience of engineers in charge of gas-driven power stations, the modern large gas engine is as reliable as a good steam engine.

Yours faithfully,
T. B. MORLEY
(GALLOWAYS, LIMITED).

Knott Mill Iron Works, Manchester, March 16, 1922.

OIL-FUEL BURNING.

TO THE EDITOR OF ENGINEERING.

SIR,—At long intervals ENGINEERING makes reference to the use of oil fuel in various connections, but it does not seem to have occurred to the bulk of engineers that they think in terms of coal, and that in the vast majority of cases boilers which are designed for the use of coal are not necessarily of the best design to suit oil fuel, and I expect it will take many years before boiler-making firms will give attention to suitable design to meet the need of oil fuel, as in a great number of cases the adaptation of coal-fired boilers for the use of oil fuel is a compromise. The cubic capacity of furnace, also its configuration, for a given duty is important as is also the draught pressure or height of chimney or funnel. There is a common notion prevalent that because oil fuel is pound for pound richer in heat units than coal, that a smaller furnace will serve for oil; this is quite the opposite of the needs of the case.

In the case of locomotive design the oversight referred to as regards want of cubic capacity in the combustion space is most flagrant, and as the various types of designs are almost endless each has to be dealt with on its merits when getting out a design for oil-burning equipment, and which at best is (because of the locomotive being designed for coal) a compromise. Given that sufficient interest was taken in the design of boilers for the use of oil fuel better results would be obtained, and millions of pounds in the fuel bill of the nation would be saved per year.

In the case of the internal combustion engine things are making progress in a natural and proper sequence, and it is recognised that no compromise will serve, but in the case of the steam engine it seems to be quite a usual practice to turn up a boilermaker's catalogue and select the size and type of boiler which will fill the needs of the case when fired with coal and use this for oil fuel.

A well-considered and suitable design of boiler for the use of oil fuel, even though it may be slightly more expensive in first cost, will, in the course of a few weeks or a few months, wipe out the extra cost in the saving it effects.

The average business man or works engineer concludes that when using oil fuel it is merely a question of burners, whereas it involves looking into boiler design and various other matters of the most vital importance, and owing to the modifications which have to be made before ordinary stock pattern boilers can be made highly efficient when fired with oil fuel it will be found that engineering experience of a wider and higher order has to be employed than is commonly supposed.

Yours faithfully,
J. J. KERMODE, M.I.Mech.E.

35, The Temple, Dale-street, Liverpool.
March 17, 1922.

"BALL AND ROLLER BEARINGS: THEIR DESIGN AND PERFORMANCE."

TO THE EDITOR OF ENGINEERING.

SIR,—I am satisfied that as indicated in my letter on the above subject in your issue of February 24, the factor 4 may be employed in general practice for arriving at the side thrust that both slotted and non-slotted single-row Rudge-Whitworth ball bearings will carry.

The value 2,200 lb. for side thrust, quoted by Mr. Macaulay, involves the assumption stated on page 591 of my paper. While fair for the purposes of comparing different types of bearing under similar side thrust, this assumption is obviously unfair for comparing the same bearing loaded radially at one time and axially at another; and I fail to see that the difference between the 2,200 lb. calculated and the loads applied in my tests points to any disagreement between theory and practice. These remarks do not answer Mr. Macaulay's question as set, but I believe that they deal with the question really at stake.

Yours faithfully,
RUDGE-WHITWORTH, LIMITED,
(H. L. HEATHCOTE, L.M., Chief of Research Laboratories).

March 18, 1922.

COMPRESSION OF GRAIN, BY HYDRAULIC RAMS.

TO THE EDITOR OF ENGINEERING.

SIR,—Some little time ago I read an account of a process for facilitating the storage of wheat and other grain for long periods, which was practised or intended to be practised in New South Wales. The plan was to compress the corn by means of hydraulic rams into a solid lump which could then be safely stored in an ordinary warehouse for a very long period without deterioration. Can any of your readers inform me if this plan has been adopted in New South Wales or in any other part of Australia, or any other country, and can they refer me to somebody or some book which will give full details of the process.

Yours faithfully,
ARNOLD LUPTON.

7, Victoria-street, Westminster, S.W.1.
March 17, 1922.

THE PRODUCTION OF ACCURATE SCREW THREADS.

TO THE EDITOR OF ENGINEERING.

SIR,—We notice in ENGINEERING, of March 10, a letter from Mr. A. A. Remington regarding the production of screw threads, and we agree with the writer when he states that the tap is the member which should be seriously attacked in the first place. This applies more particularly to taps manufactured in this country, as we have found from actual measurement that taps manufactured by certain American firms are much more accurate. There is no reason why this should be, if British makers would exercise more care in manufacture, and keep in closer touch with the engineering firms using their taps. It is very difficult to get the British manufacturer to supply definite limits to which the taps can be made, and any firm who have been approached in this respect have stated that they make their taps plus 0·003 in. to plus 0·004 in., or some such figure, to allow for wear and hardening. These so-called limits are, of course, useless to the engineer, unless suitable limits are adhered to on the other elements of the tap thread. We would also suggest that there is little or no inspection carried out on the finished taps, as we have checked taps which were as much as plus 0·015 in. on full, effective and core diameters, with a progressive pitch error. The great difficulty experienced in measuring taps crops up when the manufacturer persists in producing taps with an odd number of flutes, and there appears to be no reason for this, except to make it difficult to prove that the tap is incorrect.

It is, of course, quite possible to produce an incorrectly tapped hole from a correct tap, due to forcing the tap beyond the proper feed, which has the effect of thinning the thread, or to have insufficient float in the driver, which prevents the tap from centring in the hole to be tapped, and this might cause the screwed hole to be above the top limit allowable. In view of the possibility of faulty tapping, even with accurate taps, it will be necessary to carry out an inspection on each hole by means of a "Not go" plug screw gauge, otherwise the product may be found unsuitable at a later stage.

The difficulty mentioned by Mr. Remington would be practically eliminated if the tap manufacturer would adopt the following procedure:—

(*a*) Supply taps to produce screwed holes within the limits specified by the British Engineering Standards Association.

(*b*) All taps to be supplied with an even number of flutes, so that they may be readily checked by the manufacturer and the user.

(*c*) Institute a rigid system of inspection, so that taps outside the limits may be eliminated.

The inspection of taps can be carried out very quickly by means of the Wickman adjustable caliper thread gauges, which have been found by us to be particularly adapted for this class of work. We would suggest that taps which pass inspection to British Engineering Standards Association limits, should be marked by the manufacturer as such, and those taps which are rejected might be sold to users of taps, who do not require any greater accuracy than is being obtained at present.

We also agree with Mr. Remington that the ring screw gauge is not the proper type of gauge to check bolts and studs, and we are using in its place the Wickman caliper thread gauge for the production and inspection of screwed parts.

Yours faithfully,
J. ARMOUR, Planning Engineer.
D. P. MUIRHEAD, Chief Inspector.

Holm Foundry, Cathcart, March 21, 1922.

THE OPTICAL SOCIETY.

AT a meeting of the Optical Society, held at the Imperial College of Science and Technology, on Thursday, March 9, Sir Frank Dyson, president, in the chair, the following papers were presented and discussed:—

1. "*A Criticism of the Nodal Slide as an Aid in Testing Photographic Lenses*," by T. Smith, M.A., F.Inst.P., and J. S. Anderson, M.A., D.Sc., Ph.D., F.Inst.P. The nodal slide is only convenient for the examination of lenses over their entire field when these are of normal type. Collimators and lenses should in general be directed to pass through all useful light as symmetrically about their axes as possible. Failure to secure this condition may lead to an under-estimate of the excellence of good lenses as well as an under-estimate of the gravity of the faults present in bad lenses. The nodal slide may with advantage be supplemented by suitable linkages, which enable all the special conveniences of the nodal slide to be retained. Some of the possible modifications are discussed.

2. "*A Non-Polarising Spectrophotometer*," by A. J. Bull, M.Sc., F.Inst.P. The paper deals with a form of spectrophotometer in which uniform monochromatic patches of colour are compared, instead of the more usual arrangement of two portions of a spectrum. A spectrum is arranged so that the upper half has undergone selective absorption by the material under test, and a narrow region of the spectrum is selected by a slit. A split lens then forms two images of the dispersing prism face. These images are brought into juxtaposition by means of a rhomblike prism with slightly unequal angles, which corrects the divergence of the two beams produced by the split lens. Photometric balance is secured by the partial closure of the lower portion of the selecting slit.

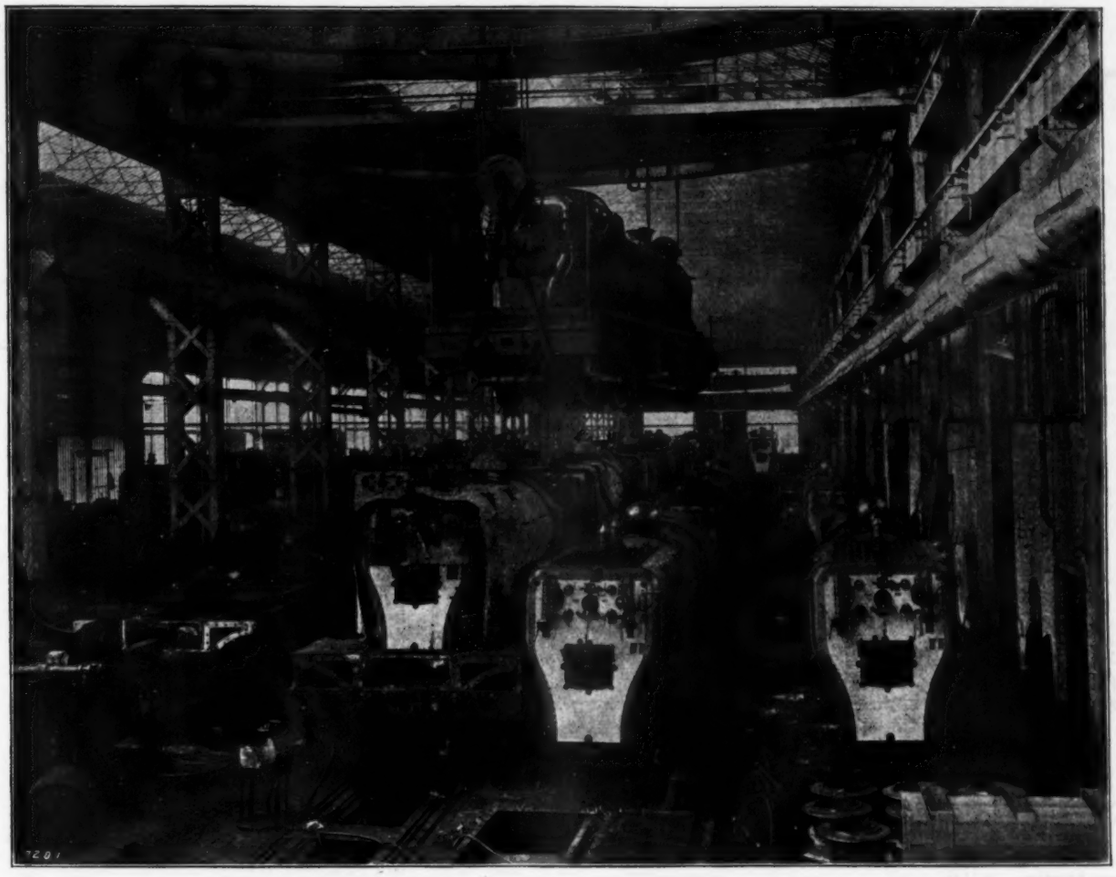
3. "*The Photometry of Optical Instruments*," by J. Guild, A.R.C.Sc., F.R.A.S., F.Inst.P. The use of a portable surface-brightness photometer of the polarisation type for the measurement of the fraction of the incident light transmitted by an optical instrument or reflected by a mirror or system of mirrors, and for the measurement of the relative brightness of different parts of the field of view of an optical instrument, is described. The instrument employed is a Wanner optical pyrometer (Cambridge and Paul Instrument Company) with some modifications to render it suitable for such work. An addition to the instrument is described which removes the danger of error due to polarisation of the incident light.

4. "*A Projective Treatment of the Submarine Periscope*," by T. Smith, M.A., F.Inst.P. The optical events which occur in an instrument such as a periscope may be illustrated by homocentric projection, and it is shown that this affords a simple means of finding the relative advantages or disadvantages of various arrangements of the optical system.

5. "*Some Measurements of the Stresses Produced at the Surfaces of Glass by Grinding with Loose Abrasives*," by A. J. Dalladay, A.Inst.P. The method of measuring the stresses at the surface of a piece of "greyed" glass is described, and measurements are given showing the relation between the size of grains of the abrasives used and the stresses produced.

THE MARINE DIESEL ENGINE.—Mr. D. B. Morison stated on the 10th inst, on the occasion of an interesting lecture in the Hartlepool Engine Works Canteen, on the subject of the Diesel engine, that he has extended to the British Admiralty, the Institution of Mechanical Engineers, and the Institution of Naval Architects, an invitation to appoint an independent committee to test the Beardmore-Tosi Diesel engines which his firm is preparing to construct for two ships that are to be built at the Furness Shipyard for Messrs. Furness, Withy and Co. This invitation has been accepted, and a committee has been appointed.

SCOTSWOOD LOCOMOTIVE WORKS: SIR W. G. ARMSTRONG, WHITWORTH AND CO.



IT will be remembered that at the cessation of hostilities, Sir W. G. Armstrong, Whitworth and Co., Limited, decided to convert their armament works at Scotswood to locomotive building. The war resulted in such a loss of rolling stock and in arrears of maintenance that at its close there was a large demand for new stock both at home and abroad. The promptness with which this fact was faced doubtless helped to bring a good deal of business to firms who realised the opportunity. At Scotswood Messrs. Armstrong, Whitworth actually commenced locomotive building while the works were undergoing the necessary reconstruction, and the first locomotive was finished and the reconstruction completed in about nine months.

Various orders have been successfully put through the works since that time. In our issues of December 3 and 10, 1920 (Vol. cx, pages 733 and 772) we illustrated locomotives of the 2–8–0 type fitted with superheaters, which the firm were then building for the Belgian State Railways. The view reproduced in the illustration above shows in the near bay another order for the same type of locomotive passing through the erecting shop. This view was taken only a few days ago and suggests that Messrs. Armstrong, Whitworth have been more fortunate than some firms in tiding over the present depression. The erecting shop consists of two bays and has accommodation for 70 locomotives at one time. The capacity of the works is about 450 locomotives a year. The erecting shop is arranged on the longitudinal system, three pits running down each bay. The outer pits are used for erecting as far as wheeling, which is done on the central pit. This pit is provided with rails to suit various gauges ranging between metre and 5 ft. 6 in. Each bay has two large overhead cranes of 60 and 70 tons capacity, while on runways below there are various sized cranes ranging from 3 to 10 tons capacity, making with the large travellers 15 cranes to the shop.

At the Scotswood works Messrs. Armstrong, Whitworth do nearly all the work involved in the manufacture of locomotives excepting boiler making which is done at the Elswick works. The Scotswood works are also served by the brass foundry at Elswick and by the iron foundry at Close Works, Gateshead-on-Tyne. The works have an area of 32½ acres, the actual area covered by the shops amounting to 175,000 sq. ft. Rail connection is with the Newcastle and Carlisle line of the North Eastern Railway, while the location has the additional advantage of a river frontage of 4,600 ft. Power is obtained from the Newcastle Electricity Supply Company, at 6,000 volts. There are four substations on the works, three of them transforming to 440 volt A.C., while the fourth converts to D.C., by means of rotary converters, for variable speed motor drives. For lighting the A.C. system is supplied at 110 volts through special transformers.

The works are provided with a well-equipped forge and smithy in which the plant includes 10 air hammers and eight stamps. The shop is served by five electric overhead cranes, one bay being equipped with the necessary tools for die sinking for the stamps. Air for the forge and smithy is finished by two Armstrong and Main compressors together of 3,000 cub. ft. per minute capacity. The machine shop is well equipped with modern tools, several special machines having been designed and constructed for Scotswood, by the firm's works at Openshaw. The frame shop, tool room, etc., are all well furnished with modern appliances, the conversion of the works, of course, enabling the firm to introduce the latest types of machines embodying the most recent practice.

The boiler work is done at Elswick, as already explained, where the equipment is likewise up-to-date, and includes all machines necessary for boiler plate work, including an 800-ton flanging press, boiler shell drilling machines of large capacity, riveting machines, bolt and stay-making machines, &c., this department being served by 15 overhead cranes of from 2 to 30 tons capacity, in addition to smaller cranes. The pneumatic equipment is supplied from compressors of a capacity of 3,000 cub. ft. per minute.

RAILWAY CONSTRUCTION IN ICELAND.—The Iceland Government has applied to the Norwegian State Railways for engineers to be sent to Iceland in order to prepare plans for railway construction, which will commence at Reykjavik. The engineers have been selected and will shortly proceed to Iceland.

AMERICAN WARSHIP PRACTICE.*

By S. V. GOODALL, R.C.N.C.

(*Concluded from page* 323.)

The battle cruiser, among all surface warships, provides the most difficult problems. The science of naval architecture will be so much the poorer for the ante-natal death of the "Lexington" class shown in Figs. 18 to 20 on next page. Without previous experience of battle cruisers, the United States naval constructors, with a courage that demands admiration, proposed to produce a vessel of the largest size and highest speed carrying the heaviest guns. The performance of these vessels on service would have been followed with the greatest interest, as they would have provided most useful lessons.

The original design was prepared at a time when high speed, heavy armament and little protection were the fashion for battle cruisers. Our own "Repulse" and "Courageous" classes date from this period. The vessels then had a speed of 35 knots, mounted twelve 14-in. guns in four turrets, and had a 5-in. armour belt, with little under-water protection beyond the usual watertight subdivision. The scantlings were very light, a maximum stress of 14 tons per square inch being accepted on the usual assumptions. The most extraordinary feature was probably the boiler installation, which consisted of 24 boilers to develop 180,000 shaft horse-power. Some of these boilers were above the water line; there were boilers on two storeys—so to speak. This scheme naturally provoked strong criticism, and the first change made was to reduce the number of boilers and increase the size of each unit; there were then 20 boilers. The main armament was altered to eight 16-in. guns in four turrets. The next change was to provide underwater protection by bulging and to increase the thickness of armour to 9 in.; increased displacement and reduced speed were accepted. This was the condition of the design when I left the United States.

Since then, further modifications have been made, and an official drawing which has been issued shows these modifications to be considerable. Apparently, the depth has been somewhat increased—presumably for strength purposes—and the armour belt has been sloped outwards as in our own Repulse and Hood.

The leading particulars of these ships now are :—

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* Lecture delivered to the Portsmouth Engineering Society, January 31, 1922.

AMERICAN WARSHIP PRACTICE.

Fig. 18. U.S. BATTLE-CRUISERS.

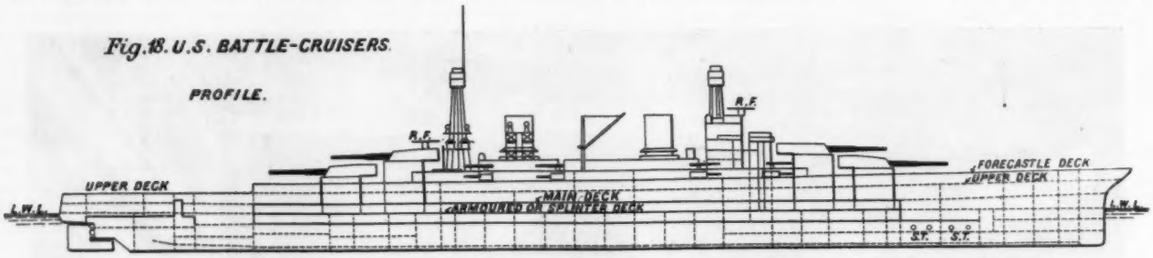


Fig. 19.

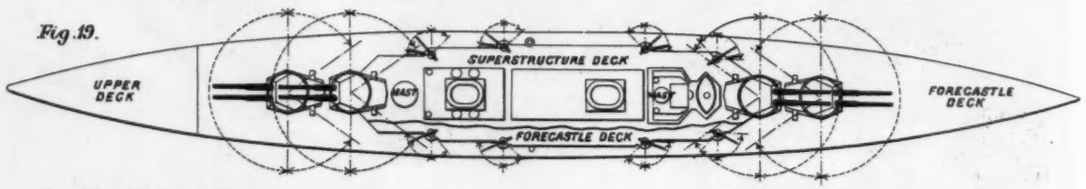
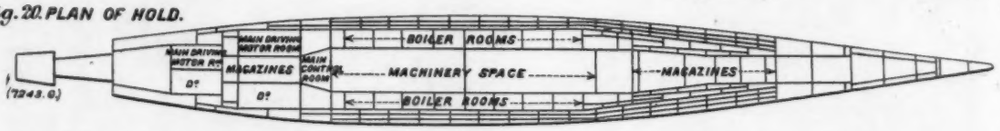
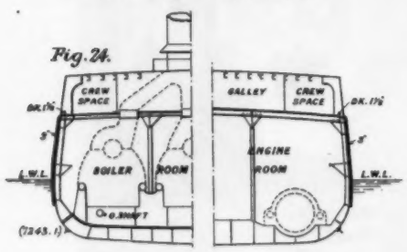


Fig. 20. PLAN OF HOLD.



SEC. AT A-A. SEC. AT B-B

Fig. 24.



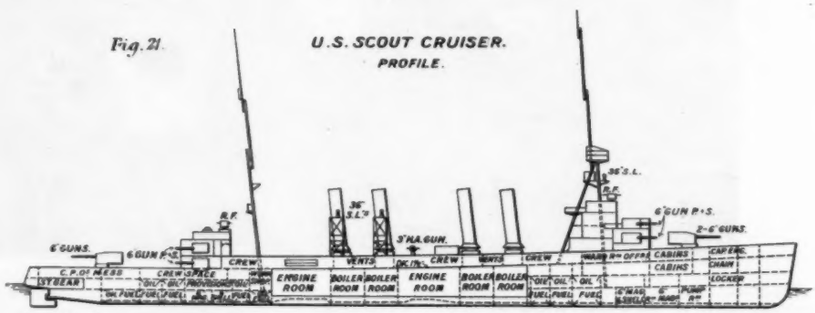
Length on waterline		850 ft.
Maximum breadth		105½ ft.
Draught ...	...	31 ft.
Displacement	...	43,500 tons.
Armament ...	...	Eight 16-in. 50-calibre guns.
		Sixteen 6-in. 53-calibre guns.
		Four 3-in. H.A.
		Four submerged and four above-water torpedo tubes.
		Two aeroplanes.

The shaft horse-power of the machinery remains at 180,000, giving a ship speed of about 33½ knots. This machinery comprises 16 oil-fired boilers, four turbo-generators and eight motors, two on each shaft. No information has been published concerning the protection. By sloping the belt, its effectiveness is increased so that it may be less than 9 in., which was the thickness in the 1918 design when the armour was vertical; it is almost certainly greater than the original 5 in. From an estimate of the weights involved it is deduced that a 9-in. belt in association with a 2-in. deck is possible; if the thickness of the side armour has been reduced for every 2 in. off this belt about ¾ in. could be added to the deck. Under-water protection is similar in principle to that of the battleships, but not quite so complete.

The most interesting feature of these ships would have been the machinery. The weight and space allowed are both extremely small and, per shaft horse-power, are not much more than those for H.M.S. Hood, but the weight and size of the boiler (each developing 11,250 shaft horse-power) is largely responsible for this, and the installation of such a unit would have been a very bold experiment. The machinery spaces, particularly the motor rooms, would have been very cramped and removal for repairs a big undertaking. Of course, it is easy to criticise a battle cruiser and, in this particular case, it will be generally admitted that protection has been mercilessly sacrificed to obtain speed and gun power.

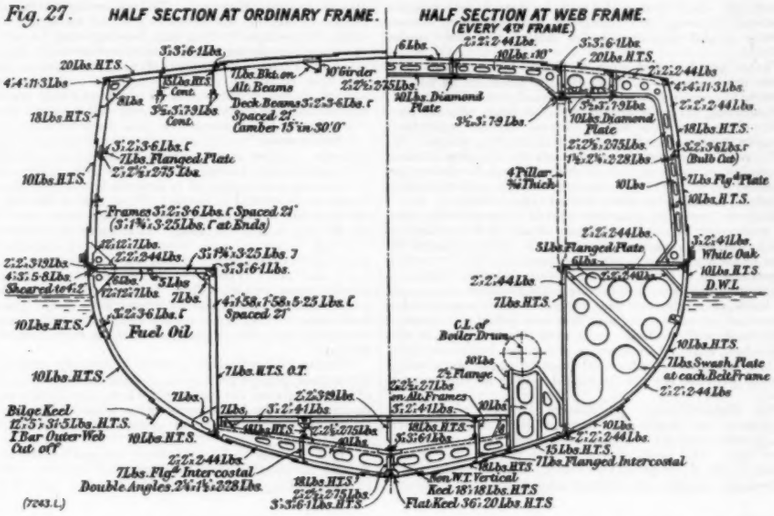
The "Omaha" class of light cruiser will be completed and their performance will also be watched with interest, for, like the battle cruisers, they are bold designs. These vessels also have been modified since they were first designed; they were to carry eight 6-in. guns and have a speed of 35 knots. The ratio of length to depth was considerable and the stresses accepted very high. I understand they have been strengthened, particularly at the fore end of the forward boiler room, where, owing to the termination of the side plating, there was ominous discontinuity of strength. The armament has been

Fig. 21. U.S. SCOUT CRUISER. PROFILE.


R.F.
R.F.
36" S.L.
3" H.A. GUN.
6" GUN P. & S.
2-6" GUNS.
6" GUNS.
6 GUN P. & S.
CREW
CREW SPACE
ENGINE ROOM
BOILER ROOM
BOILER ROOM
ENGINE ROOM
BOILER ROOM
BOILER ROOM
CREW
CABINS
CABINS
CHAIN LOCKER
OIL FUEL
OIL FUEL
OIL FUEL

AMERICAN WARSHIP PRACTICE.

Fig. 27. HALF SECTION AT ORDINARY FRAME. HALF SECTION AT WEB FRAME. (EVERY 4TH FRAME.)


Frames 3'.2'.3·6 Lbs. ℄ Spaced 21"
(3'.1¾'.3·25 Lbs. ℄ at Ends)
Fuel Oil
Deck Beams 3'.2'.3·6 Lbs. ℄ Spaced 21" Camber 15"in.-30'.0"
Bilge Keel 12'.5'.3·5 Lbs. H.T.S.
I Bar Outer Web Cut off
7 Lbs. Flg.d Intercostal
Double Angles 2'.1½'.1·228 Lbs.
Flat Keel 36'.20 Lbs. H.T.S.
(7243.L.)

increased and a reduced speed accepted. These vessels are now as shown in Figs. 21 to 24, and the leading particulars are as follow :—

Length on waterline		550 ft.
Breadth ...	...	55 ft.
Draught ...	...	14 ft. 3 in.
Displacement	...	7,500 tons.
Armament ...	...	Twelve 6-in. 53-calibre guns—four in two twin turrets, and eight in positions forward and aft.
		Two 3-in. H.A. guns.
		Four above-water torpedo tubes in two mountings.
		Two aeroplanes.
Protection ...	...	A short but wide belt of plating having a total thickness of 3 in.

The machinery is to develop 90,000 shaft horse-power, giving a ship speed of 33½ knots. This machinery comprises 12 boilers in four boiler rooms (three boilers abreast) and four sets of geared turbines in two engine rooms. The arrangement of machinery spaces is of particular interest. It will be noticed that damage to one important bulkhead will not put more than half the machinery out of action, but that this has involved two sets of boilers being placed above the wing shafts.

The United States Navy is strong in destroyers, and their constructors have been very successful with this type. One of the latest class is shown in Figs. 25 and 26, and the following are the leading particulars :—

Length on waterline		310 ft.
Breadth ...	...	31 ft.
Draught ...	...	9 ft. 4 in.
Displacement	...	1,215 tons.
Speed ...	...	35 knots.
Armament ...	...	Four 5-in. guns.
		One 3-in. H.A.
		Four 21-in. triple torpedo tubes.

The machinery, which develops 27,500 shaft horse-power, comprises four boilers and two sets of geared turbines. Compared with British practice the following are the most notable features : The shape of stern and rudder is similar to our light cruiser practice, and this, in association with the considerable length, makes the vessel less handy than a British destroyer, the steering engine is right aft in a position which involves a vulnerable length of steam piping and an uncomfortably hot compartment aft, naturally difficult to ventilate and not easily accessible at sea in bad weather. The engine rooms are relatively longer than those of British destroyers, and this results from the American dislike of our practice in placing the condenser below the turbine, and giving the shaft considerable rake. American designers consider that such a raking shaft adversely affects propulsive efficiency. Although the engine rooms are long, the vessel is designed with ample stability to guard against the risk of capsizing if extensively flooded. The arrangement of torpedo tubes is such that a mounting can only be used on one side of the vessel. The flush deck right fore and aft gives high freeboard amidships and a deep girder for strength. The accommodation for officers is forward, with some of the crew forward and some aft.

The structural arrangements are indicated in Fig. 27. The scantlings generally compare very closely with our practice, but lightening holes are cut wherever it is thought possible to allow them. In a destroyer, the saving in weight is no doubt justified, but particular care must be exercised not to overdo this. The United States destroyers stood up well to their trying work during the late war, the one or two instances of structural weakness which developed were quite local, and, in my opinion, due to a feature such as this.

In conclusion, I must refer to the chief constructor of the United States Navy, who is responsible for the vessels I have described. The name of Admiral D. W. Taylor is known all over the world. Our country can claim a little credit for his genius, since his training was completed at the Royal Naval College, Greenwich. A distinguished scientist and a gentleman, under whom it was a pleasure and a privilege to serve, he would be far too modest to make any claim upon his country's gratitude ; nevertheless, he has done such work for her as to earn a high place in the list of America's great men.

BRITISH AND AMERICAN LOCOMOTIVE DESIGN AND PRACTICE.

*British and American Locomotive Design and Practice. Some Comparative Comments thereon from Practical Experience.**

By P. C. DEWHURST, Locomotive Carriage and Wagon Superintendent, Jamaica Government Railways, Member.

THE intention of the author in placing this paper before the Institution is to draw attention to the comparative methods and practices in regard to structural and detail design of what may be termed the "British" and the "American" systems ; and to indicate what in his opinion are the best features of the two partly opposing systems of locomotive engineering. His further object is to promote discussion on the subject, his view being that some good will be derived from the ventilation of the two schools of design, by recording the methods of application in practice of each in respect to different sections of locomotive construction and maintenance.

It is no part of his purpose to deal with the fundamental principles of locomotive design, which are—or should be—the same in all countries, but to deal with their practical application. He would have wished to cover all sections of locomotive work, but such an exhaustive process is beyond the limits of a single paper, and the hope is expressed that other papers may be forthcoming dealing with other aspects of the matter, and from fresh points of view.

At the present time, when Colonial and foreign trade is of great moment, it appears that everything likely to assist locomotive builders to supply engines which will bring repeat orders from sheer merit of performance and economy of maintenance, should be brought forward. Having had the opportunity for some years of observing closely the performance of both British and American pattern locomotives under difficult conditions of curves, grades, and track, handled by native staffs, coupled with their maintenance under inadequate circumstances by only moderately-skilled workmen, on the railway with which he is connected and on which there is an unusual combination of various types of British and American locomotives, the author feels it almost a duty to record the result of his experience.

The author does not claim that the views derived from his own experience are by any means the last word on the subject, and expects many criticisms will be made by those whose experiences have differed from his, and that by eliciting such, the subject may be fully thrashed out and the consensus of opinion thus obtained may be of sufficient weight to be authoritative, as he believes it is only by combination of the practice of the two countries that the best results can be ultimately attained. It is instructive to observe at the present time how a number of features of proved worth have been adopted by one country from another ; undoubtedly this is as it should be, and those who are most successful in adopting the good and eliminating the poor features of each practice, will lead in locomotive construction.

It may be considered that the paper consists mainly of a record of the author's opinions, and this is correct to a degree—the whole subject is really a matter of opinions—and those given in the paper and the reasons therefor, are based on experience of actual running and maintenance, in the majority of cases under similar working conditions. In such a wide subject it has not been possible to notice all parts of locomotives, nor to notice all the variations in respect of the different items dealt with.

General.—It is not intended to refer at length to the difference between the present British locomotives and the enormous engines now used in America, as this difference is almost entirely due to the relative topographical relationship of the railways of each country to the areas they serve, the British lines being more of an intensive system and not lending themselves to long, heavy hauls, as are common in America. Where the latter conditions are developing in the Colonies and elsewhere—as in India and the Argentine—British locomotive builders are producing proportionately larger locomotives to meet the necessities of such services.

At the same time the author's opinion is that in England much greater use could be made of powerful eight-coupled engines—with additional idle axles if necessary, on account of axle-weight limits, or even ten-coupled—together with high-capacity (and comparatively low tare) wagons, on coal and similar traffic in large, compact loads for reasonably long hauls. Great economies in the occupation of congested main lines, coal and oil consumption, repairs, and in enginemen's and others' time, could then be effected. To build goods locomotives of a capacity limited by six wheels and, with the assistance of a pilot, to haul long trains of minerals in wagons containing about 10 tons, with a tare of about 6½ tons each, as is done on some British lines, appears to be entirely out of date ; presumably bridges of insufficient strength are the cause of such working. If this is the case, it would seem that the money wasted each year by uneconomical working would, if capitalised, cover the cost of renewing or strengthening a good number of weak bridges.

Methods of Designing.—The American system, where locomotive builders supply engines to general instructions, without the railway concerned furnishing fully detailed drawings before the engines are constructed, is not so satisfactory as where the whole of the design, including the details, is in the hands of the railway. It results in important items which could with advantage be made the same on different classes of engines on the same railway, frequently not being so made, and in smaller details such as lamp brackets, engine and tender couplings, hoses, &c., which for obvious reasons should be identical throughout a particular railway, often being supplied with variations on different orders, and which, in some cases, differ on the engines of repeat orders of one design.

Although the builders and the railway officers keep in touch as much as possible, and the builders are always anxious to fall in with the suggestions made to them, yet it is not so advantageous as when the whole of the design is actually in the hands of those who will have to operate and maintain the engines ; they alone can make all necessary allowances for working-in standards already existing, for special service conditions, and for the facilities or limitations of the repair shops.

Subject to the amount of control indicated above, the builders supply to a great extent what is most suitable from their own point of view, in the way of axle-boxes, springs, coupling rods, brake gear and similar parts, and this leads to considerable unnecessary variation ; thus maintenance and service suffers for the sake of first cost. Designs made without full knowledge of all the conditions to be met, or not fully considered from the maintenance point of view, should never be placed on any railway. Engines designed with the view to their economical repair (and long wear in service) save the extra cost of such designing the first time that repairs of any extent are carried out.

Of course it may be said that the American Railway Master Mechanics Association, by its system of circulating proposed alterations to standard details, before these become "recommended practice," goes much further in the way of reducing unnecessary variations. However, this is only true to a degree ; for instance, it is no consolation to a comparatively small railway, when it has axle-boxes, big and little ends, coupling rods, brake gear, &c., of two different classes of engines, say, 4-6-2 and 4-8-0, which might have been made to interchange but varying in small degrees, to know that such parts supplied were the Master Mechanics Association practice for each of the respective classes.

Features of American Locomotives Popular in Recently-Developed Countries.—Against this, however, must be set some important features of American design which make it popular in recently developed countries. Before mentioning these, however, it is necessary to refer to the fact that it is often said incorrectly in connection with their advantages for new and difficult lines, that the bar-framed engine allows greater flexibility both vertically and laterally than the plate-framed engine. This, however, is not a function of bar-framing at all, which, in fact, is more rigid laterally, and (when the horn-stays are in position as when running) quite as rigid vertically as the plate-frame ; the former advantage referred to, being due to the employment of flangeless wheels and other devices, the latter being due to the compensating of the spring gear.

Their real advantages in this respect are : (1) Compensating gear in the spring rigging which gives an easy-riding engine even on poor track, and prevents a large

* Paper read before the Institution of Mechanical Engineers on Friday, March 17, 1922.

proportion of the derailments which happen to uncompensated engines on such tracks; (2) the very substantial and rigid support given by the horn blocks (or shoes and wedges as they are termed), which are an inherent feature of the bar frame, and which have no frame bolts to work loose; (3) the design of axles and axle boxes which have adequate bearing area, provides opportunity to allow ample side play without unduly reducing the bearing area; (4) the use of flangeless wheels; and (5) a generous allowance of boiler power, enabling poor fuel to be used. All these features, with the exception of (2), which, however, is overcome in other ways, are as easily obtained in the British plate-framed locomotive, as will be shown later, under their respective headings. Outside cylinders are not regarded as particularly American practice in respect to new countries, as in British practice, also, outside cylinders are always now used for such work.

Boiler Power.—The author considers the American practice of providing a larger proportion of boiler capacity for a given cylinder capacity than in British practice, is the better policy, and even after allowing for the generally inferior quality (in respect of size, not necessarily composition) of coal used in America, there is still a large difference. It may be said that the British practice is to employ relatively large cylinders, in order to obtain economy by using a very early cut-off, by this means the cylinders are worked proportionally to the steam production of the boiler. In this way a large proportioned—and therefore heavy and costly—engine is not made full use of, and exerts only a part of its nominal power for sustained periods.

The general effect on the British locomotive, until recent years, has been that engines dropped behind in boiler capacity until only the full nominal cylinder capacity was equal to meeting the demands of traffic, with the consequence that boilers were overtaxed and the economy which might have been obtained from the relatively large cylinders, was probably lost by the reduced boiler efficiency. If a boiler is provided which has to produce almost its maximum amount of steam to supply the normal demands of the cylinders, and has to be "thrashed" to suit heavy loads, the result is certain to be wasteful in both fuel and maintenance.

Dome Position.—The dome is almost always located approximately at the centre of the boiler barrel in British practice, whilst in America it is most often on the last ring next to the fire-box. Inasmuch as the dome exists for the purpose of obtaining the driest steam possible with a given height of water, it is difficult to see a sufficiently strong reason for losing part of this advantage by placing it near the point of greatest ebullition.

Further, the position towards the rear is a great disadvantage when starting a heavy train up a steep incline chimney first, and the author has experienced difficulties in practice in this respect. All enginemen naturally prefer to start a long severe pull with an ample supply of water, and the effect on long boilers of striking a long uphill section of 1 in 30, after the water-level has been properly adjusted on the level, inevitably leads to priming, if the dome is far back, whereas with the dome further forward the effect is actually a lowering of the water-level there.

As an instance, a boiler of a length (including fire-box shell) of 25 ft., running on to a 1 in 30 gradient, will have its water-level raised abou 5 in. at the fire-box end and lowered 5 in. at the smoke-box end; with the dome placed about 10 ft. from the fire-box back, the rise there will be about 1 in., but with the dome another 5 ft. forward there will be a fall of 1 in., in other words, a 2-in. higher water-level can be carried with the dome in advance, Fig. 1. Of course, in going up tender first, the result will be just the opposite, with the additional disadvantage that there is more danger of uncovering the fire-box crown. Against this must be set the very great advantage of the extra 2 in. of water allowed by the advanced position when the engine changes at the top of a gradient from 1 in 30 up, to 1 in 30 down, in 100 yards or so, and without stopping; this advantage quite offsets anything else. The author has known a number of cases of scorched fire-box crowns caused by the lack of room for the long axle-box bearings favoured. A few four-cylinder balanced simple engines have been tried in recent years, but the practice has not been extended.

Tank Engines.—It is surprising the comparatively little use made of tank engines in America; the 0-6-0 standard shunting (or switching) engine in particular has always been fitted with an eight-wheeled tender, and the latest classes of heavy 0-8-0 switching engines perpetuate this. There are, of course, many 0-6-0 tank engines used by industrial firms, but locomotives owned and used in railway service are referred to. Whilst these later locomotives are already sufficiently heavy for the four axles, and adding the water and fuel on the engine would produce excessive axle weight, yet there seems no reason why pony trucks or a bogie could not be added, and so get everything on one frame. There is no question that a self-contained unit is preferable for shunting, for obvious reasons; in addition, an appreciable saving would be found in the draw-gear, water, brake and other connections between engine and tender, also a saving in weight wth lesser number of wheels and axles, &c.

In regard to short trip and branch passenger services, it is possible that they are sufficiently provided for in America by ex-main line passenger engines relegated to lighter duties, but against this is the lesser life of American locomotives compared with British, which would lead one to expect a larger demand for passenger tank-engines in America.

One interesting fact in connection with most American-built passenger tank engines has been the custom of using "mixed" frames, the bar frame as a rule terminating just behind the fire-box, from which place a plate framing was bolted on and extended to the rear of the engine. The point of junction seems generally to have been the weak spot, and one is inclined to question whether this may have influenced the ordering of tank engines on the principle of "giving a dog a bad name." The few later examples of these tank engines, with a trailing bogie or truck have, however, been constructed with bar-framing through to the rear. The author considers that for short trip and shunting engines, the British practice of employing specially-designed tank engines is much more advanced.

Outside Cylinders.—The placing of the cylinders outside has always been the standard American practice, and after many changes in British practice, extending over a considerable number of years, the inside cylinder seemed to have become supreme, but the tendency there is also in the same direction. The advantages of the outside position, namely, the absence of crank axles, the facility with which ample driving axle bearings may be provided, the machinery being outside and therefore easily inspected, oiled and repaired (especially if, as is standard in America and now becoming usual in England and the Colonies, &c., Walschaert valve gear is employed and the valves placed over the cylinders), are very real indeed, especially in countries where inspection pits are scarce.

The "nosing" or "boxing" at the front end of outside cylinder engines is considered to be principally due to (1) insufficient lateral control at the bogie centre; (2) excessive sideplay of (particularly) bogie, also axle-boxes on axles and in horns; (3) (*a*) roll of driving boxes on journals due to brasses having worn too large, (*b*) driving boxes knocking. It is naturally observed to develop quicker and become more pronounced on 4-4-0 and other short wheel base engines; on 4-6-2, 4-8-0 and 4-8-2 types even when badly run down, it is hardly perceptible. The "three-point" or double-suspension hanger type of swing link bogie gives the least opportunity, in the author's experience, for "nosing" of outside cylinder engines, as is to be expected from its design.

Placing the cylinders outside is entirely preferred by the author, except perhaps in certain cases of locomotives of medium power for fast work, where the slightly steadier running and the better protection from radiation losses make it worth while to accept the attendant disadvantages

There is little to be said when comparing the modern British method in the installation of outside cylinders, of employing separate castings for the cylinders and steamchests on each side, and a box casting between them under the smoke-box, with the American method of using two castings only, meeting in the middle and forming a saddle between the frames for the smoke-box. The methods are conveniently applicable to the plate and bar frames respectively. The American method possibly gives rather more weight at the leading end—where it is not wanted—but it is doubtful if this comparison holds good when the British arrangement includes a saddle casting for the smoke-box.

A very good feature of modern American practice is to design cylinders with renewable liners; this, in addition to providing for future wear, also allows the cylinder casting to be of tougher, but less hard, metal than would otherwise be the case.

Slide bars of outside cylinder engines seem to be more susceptible to wear, and occasional overheating, than do those of inside cylinders, probably because these cylinders being generally lower down than inside ones the bottom bars are nearer the ground; reference to slide bars is made farther on.

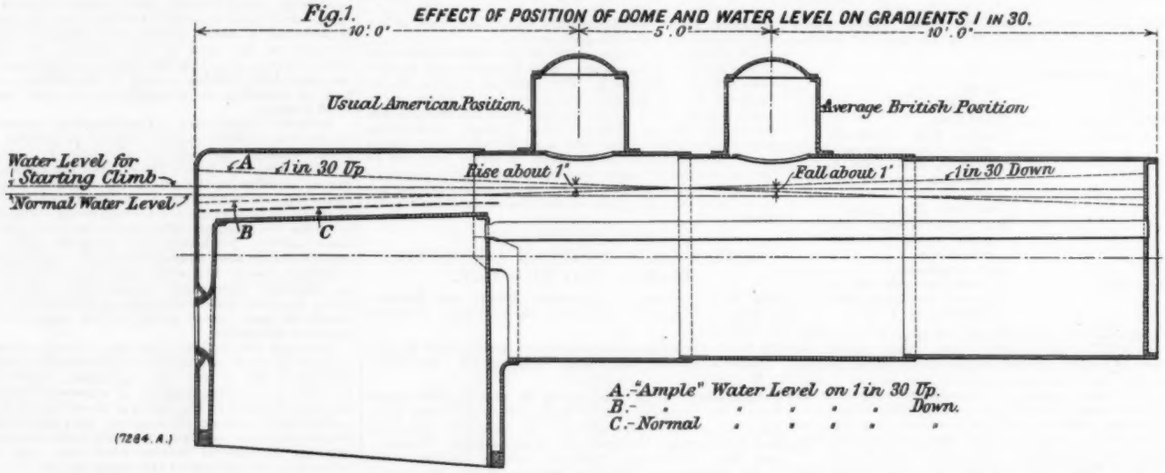
Main Frames: Plate; Bar.—Comparing the plate-frame of British practice and the bar-frame of American, the plate-frame has the advantage of a certain amount of lateral elasticity, which is of advantage on curves, although it is probable this lateral elasticity or "whip" is sometimes the cause of axle-boxes overheating. Cutting out very large spaces in the frames and employing coupling rods of too (comparatively) rigid I section will render an engine liable to this trouble. The bar frame also has its advantages, particularly in respect to the axle-box attachments, certain features arising out of the top of the frame being much lower than with plate frames. There is also the possibility of arranging the spring gear in its open spaces. The principal advantages and disadvantages of the bar-frame are as follow:—

Advantages —

(1) Distance between top of horn space and top of frame being very small, allows springs to be overhung, except where the fire-box is situated; this is convenient when wheels are small and underhung springs would be cramped for room and difficult to examine without a pit.

(2) Frame spaces allow springs under fire-box to be

Fig. 1. EFFECT OF POSITION OF DOME AND WATER LEVEL ON GRADIENTS 1 IN 30.



placed in them, and provide space for compensating beams, &c.

(3) Provides a strong and effective system of horns by means of very simple shoes and wedges.

(4) Allows fire-box shell to be as wide as can be got between backs of tyres in some cases, and in others where the coupled wheels under the fire-box are small enough, it allows for the fire-box to be over the wheels without much raising of the boiler centre.

Disadvantages :—

(1) Very weak in a vertical direction, and if care is not taken in shops the single top rail over the horns may get crippled—similarly any slackness developing in the hornstay (or pedestal brace as it is called) overstrains the same part.

(2) Has excessive lateral rigidity compared with plate-frames; does not "give" slightly on curves at speed.

(3) Restricts any between-frames fire-box shell to such an extent as to prohibit the use of such fire-boxes in modern-powered engines.

(4) The front end section beyond the cylinders is usually weak.

Further reference is made, in the appropriate sections, to the various detail features connected with the framing question, but it is convenient here to deal with the fire-box question in relation to the bar frame. The narrow fire-box difficulty seems to be at the root of the American preference for types of locomotives with an idle trailing axle, which enables a wide fire-box to be placed over the rear wheels. There seems no doubt that, but for this it would be preferred to eliminate the idle wheel, thus reducing the number of axles, or alternatively to place an additional coupled wheel there. In other words, the narrow fire-box difficulty produced by the use of bar framing was principally responsible for the original employment of the idle rear wheels.

Of course, this does not apply to the special fire-boxes designed to burn low-grade fuel, nor to the huge locomotives now employed in America having fire-boxes beyond the possibility of being placed in the old position with any description of frame; but there are many engines of moderate size, particularly of the 4-4-2, 4-6-2 and 4-8-2 types, which need not have the idle trailing wheel but for the bar-framing, and the loss caused by them is an important point adverse to the bar-frame. In the past the simplicity with which a plate-frame could be repaired compared with a bar-frame gave the former a certain advantage, but now that effective electric and other autogenous welding is common, this is no longer the case.

Horns or Pedestals.—Reference has already been made to these details under "Frames." With American bar-frames the general width of axle-box vertical wearing surfaces is 5½ in., this is narrower than the usual British practice, and is due to the shoe face being governed to some extent by the width of the bar-framing, whereas the separate horncheek of the plate-frame system is usually about 6½ in. wide. The advantage here is with the plate-frame system, but in practice this is more than offset, as wear is easily taken up with the bar-frame system, particularly on account of the front face or "shoe" being readily detachable without disturbing any driven frame bolts.

Regarding the wedge side of the horns, the difference consists in the wedge forming the wearing surface against the axle-box being held in position laterally, by a wide tongue let into a groove in the horncheek behind it, in the plate-frame system, as against it being held in position by lips on each side of the bar-frame, in the other. The British system again provides the greater bearing area, but the American provides better support for the wedge against side thrusts of the axle-box; the wedge side of the horns are as lasting as the shoe side, whereas the author has found the British pattern of wedge liable to develop considerable lateral displacement under severe track curvature conditions.

The bar-frame, by giving very substantial support, and in allowing "shoes and wedges" to be applied without any fixed bolts or rivets in the frame, scores an important point in its favour; there are no frame bolts to give trouble by working loose, and the horns are very conveniently lined up between the back of shoe and the frame, thus forming a simple method of taking up further wear when a wedge has reached its limiting position of adjustment. This removable shoe system allows the lining-up and re-centring of a whole set of wheels and axle boxes without taking the wheels from under an engine; wedges are always used.

The plate-frame type of horns as usually designed, can be arranged to meet the necessary conditions (except detachability of the front surface), by providing substantial hornecheeks, with very strong and stiff hornstays composed of horizontal bolts and distance pieces. The old pattern of hornstay, composed of a plate or forging held up by 1¼-in. studs at the base of each horncheek is quite insufficient; further, it is most essential that the frame bolts are well spaced and have full parallel holes in the frame—they may have shallow heads outside, but the length of fit should on no account be reduced by countersinking; horns will not stand up to their work on severe curves unless the above points are attended to. Riveting-on horncheeks proves quite a failure in such cases.

Axle-Boxes and Journals.—Not much comment is necessary in respect to the constructional features of the axle boxes employed by each country; cast steel for the body is now customary in each case, but the methods of inserting the brass differ. In British practice this is usually of a square-backed pattern bedded into the crown of the box so as to make a tight fit with the keep in position; the American method is to use a semi-circular crowned brass, and to obtain the fit in the box by inserting it in from the side, under pressure; a further difference is that in the former case the brass is prevented from moving laterally by locking grooves in the crown, whilst in the latter, brass pegs are inserted from the body of the box into the brass when in position.

In American practice plain brasses without anti-friction metal insets are generally used, thus differing from British practice, but the experience of the author is in favour of metal pockets, as not only do they tend to keep a box from running hot, but should this happen, the axle does not get so badly scored as when solid brass bearings are employed. Axle-box keeps—or collars as termed in the United States of America—are in American practice always removable *in situ*.

Contrasting the different methods of providing side-wearing surfaces, generally speaking the British practice is to depend on a small arc on the brass itself on the outside of the bearing, and an even narrower arc on the inside, butting against the shoulder on the axle, plus the radius in each case. The American practice is to have a very large wearing surface (of brass) attached to the side of the box on the outside only, no provision existing for taking up side thrusts on the inside. There is no radius either outside or inside, and usually no bearing on the side of the brass at all.

The effective differences are, therefore, that the brasses of both boxes take the lateral pressure and transmit it through the boxes to both frames in British practice, whilst it is taken up direct by one axle-box and transmitted to one frame only in American practice. The taking up of the side thrust by one frame only is possible owing to the lateral rigidity of the bar frame, and the very effective cross-staying possible with outside cylinders.

COMPENSATING GEARS.

Fig. 2.

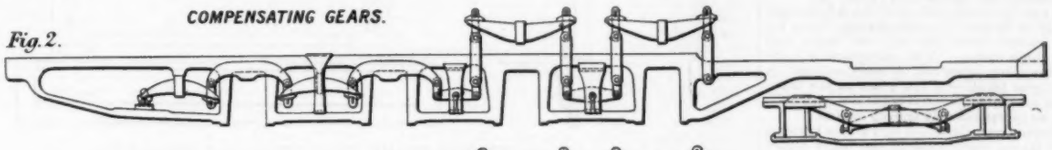


Fig. 3.

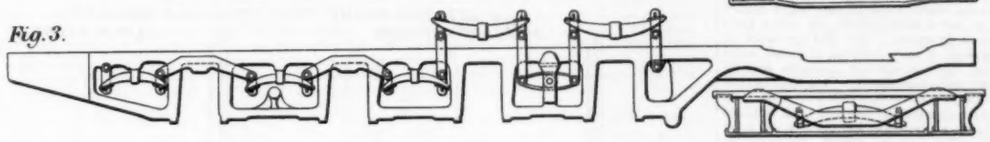


Fig. 4.

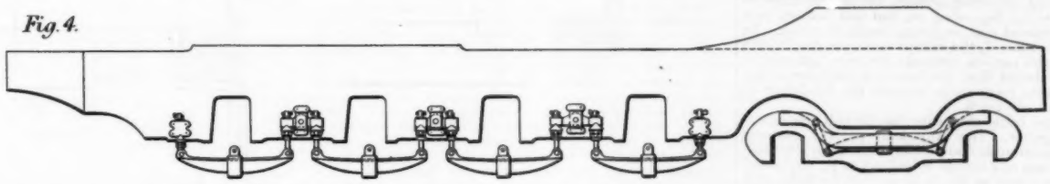


Fig. 5.

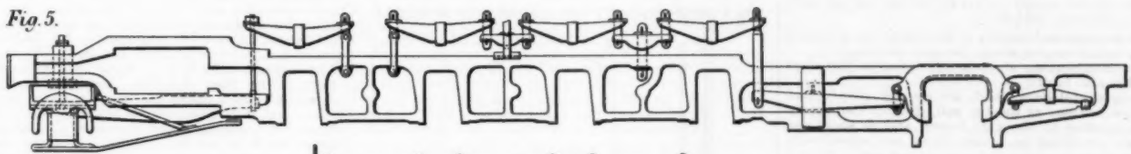
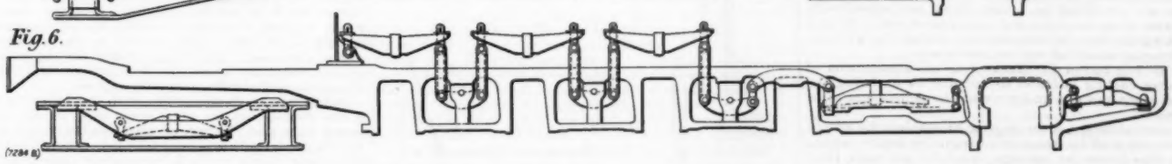


Fig. 6.



(7284 6)

The author has experience of locomotives working over extremely sharp curves quite satisfactorily with the American type of axle and axle-box, whilst other similar type locomotives with the British pattern suffered much from quick wear on ends of brasses, and gave trouble from overheating, until the axle boxes were provided with side liners similar to the American arrangement, after which the trouble ceased. In particular the slackening of brasses in the axle boxes also declined.

The balance of favour is considered to be with the American system, as being better both in principle and practice, but the author considers the two methods complementary and not necessarily alternative.

Compensating or Equalising Gear.—The employment of compensating arrangements in the spring rigging of all locomotives is the outstanding feature of American design, and, as already mentioned, has undoubtedly had great effect in obtaining the American locomotive's good reputation in countries having new and difficult tracks. In long and multi-wheeled locomotives it can be clearly observed that the levers assist the easy riding of the engines almost as much as the springs themselves, and the manner in which a defective high spot in the track passes along and articulates the whole compensating gear when passed over at speed, is conclusive.

As mentioned previously, compensating gear is not a necessary corollary of the American bar-frame, or *vice versa*, and similar results can be obtained with the British plate-frame locomotive, the compensating gear being almost as easily worked in with plate-frames, except in cases where owing to small diameter of wheels the springs cannot be underhung, and a side-overhanging fire-box prevents the springs being applied above. In

such cases the spaces in the bar frame provide a position for both springs and compensating gear—the springs themselves sometimes forming an equalising beam. A way of overcoming this difficulty with plate-frames, where there is insufficient space for the springs inside the frame, is to fit only the compensating beams at the awkward place, carrying the springs themselves at each end of it.

Typical instances of compensating arrangements are given in Figs. 2 to 6. Fig. 2 shows the usual arrangement for a 4-8-0 type locomotive, and clearly indicates the use of the spaces in the frame to allow the fire-box to set over the frame. Fig. 3 is of the same type, but noteworthy for the provision of three springs for the two rear axles, and Fig. 4 shows a similar type of British plate-framed engine as equalised by the author. In Fig. 5 is given a compensating system for a 2-8-2, in which it is to be noted that the continuity is broken between the first and second coupled axles, and in Fig. 6 is seen a system for a 4-8-2, in which the combined spring-cradle compensator (not equaliser) between the rear coupled axle and the back truck, provided to act for the rear coupled axle, is specially interesting.

It may be noted that pony trucks are always compensated with the axle next to them, but bogies are usually—but not always—isolated from the main compensation group.

Although the author is aware that the system entails more wearing points—not necessarily pins, as "V" edges and rollers can be employed—yet the advantages are such that he is in favour of compensating levers for all locomotives, except those having few axles and designed for very high speeds. This exception is made on account of a tendency observed on such engines for the compensating gear to allow a low place in the track to affect the roll of an engine, when it coincides with such roll, more than in an independently sprung engine.

Bogies, Bogie Frames and Parts.—The various systems of controlling the lateral movement of the bogie centre are too well known to need description, all being used in British and Colonial practice. The sliding table or "Adams" type, however, is very seldom, if at all, used in American practice, the swing-link pattern having been always practically universal there. It is remarkable that quite often, even down to recent years in American practice, no differential spacing of the top and bottom pairs of pins, nor double suspension hangers, were used to provide strong centering powers, the simple force of gravity alone being depended on, top and bottom pins being equally spaced and no spring check provided. In respect to bogie control, the author considers the British application of the various methods the best, although it must be remembered that the longer wheel base of the average American locomotive reduces the tendency to "hunt" on straight track.

Regarding the bogie structure the British pattern is considered superior. The American pattern consists of a bar framing running completely around the top part, with pedestal bars or castings bolted under it, connected together on each side at the bottom with tie bars, and having the centre casting bolted to the top bar (or rail). It has the following defects :—

(1) The longitudinal rigidity of the frame being mainly in the top rail, is too far above the axle centres.

(2) The cross-staying at each end being at the same high level is also faulty.

(3) The pedestal bars which are usually simply bars of the same sections as the top rail, present too narrow a wearing surface to the axle boxes, and as shoes and wedges are not fitted as a rule (shoes are occasionally used) wear soon develops, and necessitates removing and re-working the bars, or alternatively, electrically welding-on making-up material and re-machining.

(4) The top rail of the frame near the attachment of the centre casting is liable to fail due to its being the weakest place and apt under certain circumstances to be overstressed.

The general design of the bogie assumes that the weight of the engine shall be transmitted from the centre casting to the axle boxes by springs, specially set with their inverted buckles nested directly under the outer part of the centre casting, these centre-bearing springs being an integral part of the design, and that the whole bogie frame is merely to keep the wheels in correct position and alignment. This is sound in theory, but in practice occasionally some weight actually is transmitted through the frame—as in passing over a bad crossing, which may cause the axle boxes to strike the top of the horn spaces of each axle on one side in quick succession—and as it is evident the top rail of the frame cannot alone support the weight of the engine, it eventually suffers near the centre casting.

The British pattern bogie structure appears to avoid all these troubles and is quite capable, without its springs and cradles, of sustaining the weight of the engine :—

(1) The rigidity of the frame is in the correct place.

(2) The cross stays are placed sufficiently low to prevent the lower parts of the horn spaces whipping.

(3) The horncheeks provide a good bearing area for the axle boxes, and do not usually require attention for years.

(4) The centre casting is of substantial design and is attached to the side frames right down each side ; it usually extends towards each end in addition.

It should be noted that better provision for wear is usually provided than in American bogies, and more attention is paid to the lubrication of the pins and of the centre itself ; the latter in American practice being considerably smaller in diameter than in British, and without the usual substantia lcentre socket to the casting.

Pony Trucks and Radial Axle Boxes.—Radial axle boxes are rarely used in American practice, whereas pony-trucks are made very considerable use of, in fact nowadays there are probably more locomotives there fitted with pony trucks than bogies. Three-point suspension links are being applied to pony trucks in the latest practice as in bogies. The author, unfortunately, has had no experience with radial axle boxes, but from careful consideration of all the points, they appear to have no advantage over the pony truck, provided the pony truck is designed in a sufficiently substantial manner.

He finds that the two-wheeled truck does not by any means give results equal to the bogie on severely curved lines, for the reason that the limit of weight on one axle will not keep the flange down, if it is attempted in designing the control to cause the truck to do all the work of curving the engine, and in practice this results in the pair of flanges next after the pony truck doing considerably more curving work than the truck itself. It is impossible to have a flangless wheel next to the pony truck, thus preventing as short a rigid wheel base being obtained with a pony truck as with a bogie. It is significant in this connection to note that express and passenger engines in America are never now designed with leading two wheeled trucks, the 2-6-2 type having been rapidly displaced by the 4-6-2 ; and more recently, where an exceptionally powerful passenger engine is desired, 2-8-2 types are not used, but 4-8-2.

Mention should be made of a type of axle box having special lateral movement, often used in America for idle trailing axles instead of an ordinary pony truck. This is the Rushton truck and its modifications ; the arrangement gives radial and lateral movement, which is controlled by hangers depending from trunnions on the axle-box top, front and back, and pivoted at their lower ends to specially deep-arched yokes incorporated in the spring rigging ; the top trunnions, which pivot on a centre pin on the axle box to allow radial movement, are usually single, depending on the simple force of gravity to control the lateral movement, but in recent practice double trunnions, giving the same effect as three-point suspension links, are used. This truck, although performing satisfactorily within its limits, suffers from excessive wear on the pins and links, due to the dust thrown up by the whole of the engine wheels ahead, and from its proximity to the ash pan, &c. The author prefers a standard pony truck.

There is also the "Hodges" trailing truck, which is a special form of pony truck differing from the usual pattern in that the radius rods are replaced by an encircling frame which also forms the main frame and horns in one piece, this framing passes outside the wheels and the bearings are therefore also outside ; in some cases this frame does duty, in addition, as a compensating beam incorporated in the spring rigging. The author has had no experience with this truck, but from the fact of its bearings being outside and that it has no pins, &c., to collect dust, he considers it a very good type of two-wheeled truck for the trailing end, but not for other purposes.

Boilers : Construction and Materials.—The fundamental principles of boiler construction are similar in both British and American practice. The American boiler is much larger than in British practice, but this is mostly a factor of the larger locomotives and hence larger hauling capacity of the American locomotive made possible by their considerably more ample loading gauge. Special types of fire-boxes are used in American practice, but this again is a factor governed by the special fuel burnt by these boilers. The generally larger proportion of boiler capacity to engine power in American practice compared with British has been commented on previously.

Eliminating these three phases the greatest difference is in the material used. In British practice acid steel plates are practically always used for barrels and fire-box shells, while in America basic steel is permitted and extensively used. The author considers the acid process steel the more suitable, although it is fair to say that in practice the only deficiency he has observed in the basic steel has been the greater tendency to pit inside the barrel, and, to a less extent, to suffer from external corrosion under the barrel when dampness has accumulated.

The greatest difference between the practice of the two countries is, of course, in the use of steel for fire-boxes in America. This subject, together with the use of steel tubes and other subsidiary matters arising therefrom, the author has dealt with at length in a paper* before another Institution. From his experience, he finds that the copper box is superior from the point of view of ease of maintenance, facility of repair, and general dependability. The steel fire-box, however, can be quite successfully used under the most arduous service conditions and in British pattern boilers, even with the old system of patching when necessary ; with the great strides made in electric welding, however, there now seems nothing to choose between the two materials in respect to repairs. The question is whether the extra cost of the copper fire-box is justified for the sake of its greater reliability under the circumstances and character of any particular railway and its services.

Another point in connection with the American boiler, is the elimination for some years now, of all forms of crown bars and the use of direct radial stays instead. The author is quite in accord with this, seeing no sufficient advantage in the crown bars to offset their well-known disadvantages, such as scale accumulation and difficulty of access ; even in respect of the distribution of stresses in the outer shell top, the direct stays are superior. Only a small proportion of American boilers have Belpaire fire-boxes, and the great popularity of the Belpaire fire-box in British practice in later years mostly applies to railways which previously used crown bars, whereas, other railways which were using round-topped shells and direct stays have not, as a rule, adopted the Belpaire box extensively.

Prior to the general use of the wide (normal, not Wootten) fire-box, with its accompanying small idle trailing wheel, the between-frames fire-boxes were generally associated with the wagon top, and latterly with the extended wagon-top type of boiler, in order to obtain increased fire-box capacity, and increased steam space above, without increasing the diameter and therefore the weight of the boiler at the leading end ; such boilers have not been found necessary in British practice, the nearest approach being the raised fire-box type, in which the shell was raised a few inches only, above the general level of the barrel top. The exception to this rule is the present standard Great Western Railway boiler of "coned" type, which is really another form of the extended wagon top, and it is curious to note that its use came into vogue about the time that its prototype in America went out of favour.

The remaining principal difference is in the universal use in America of steel or charcoal iron for tubes, whilst British practice is still to use brass or copper. It is true that before the introduction of electric welding of steel tubes to the fire-box tube plate, steel tubes were much

Fig. 7. "BETWEEN-FRAMES" (BRITISH) TYPE EXPANSION BRACKET.

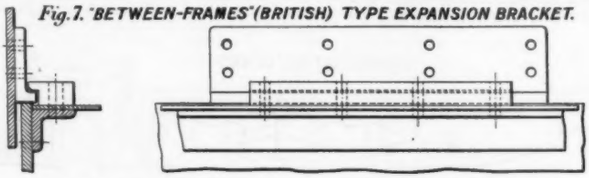


Fig. 8 "BETWEEN-FRAME" TYPE EXPANSION BRACKETS.

ORDINARY PATTERN. CLIP PATTERN.

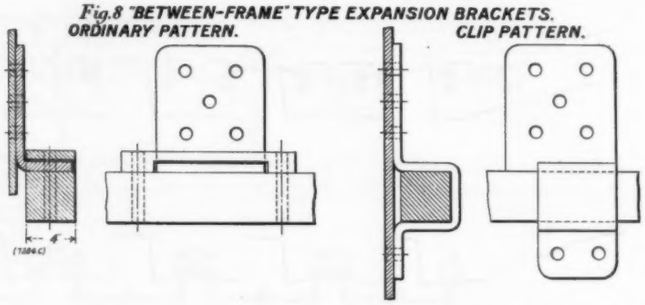
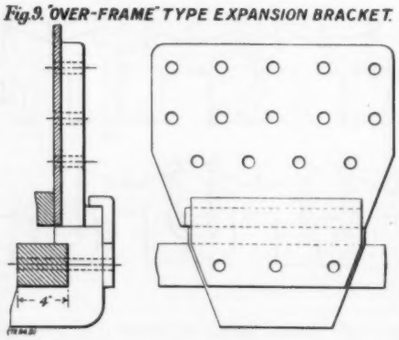


Fig. 9. "OVER-FRAME" TYPE EXPANSION BRACKET.



* Inst. of Loco. Engineers, vol. ix, No. 40, 1919.

more difficult to keep tight and rather apt to fail in service when used in steel fire-boxes; but the author has not observed any difficulty in keeping steel tubes tight in copper boxes, and hardly sees sufficient justification for the use of brass or copper tubes unless it be in respect of their better conductivity. Some experiments in actual working would be of great benefit to settle this question definitely. In any event, owing to the greater heat to which tubes are subjected and the high coefficient of expansion of copper compared to the boiler barrel it is inevitable that the tube plates will have to stand far greater distortion between cold and working temperatures when copper tubes are used than in the case of steel. Another point in favour of steel tubes is, that they do not suffer from the eroding at the fire-box end just inside the tube plate; this is an important advantage with engines engaged on heavy work at long cut-offs.

A very great amount of autogenous welding is now practised in American boiler work, whole fire-boxes having their various parts welded up so that no laps or rivets exist anywhere. The author considers it too early to pronounce an opinion on the entire success of this; it is very alluring and from the good results obtained in patching fire-boxes by its use, appearances were all in its favour, but he observes from recent reports of locomotive boiler explosions in the United States of America by the Bureau of Locomotive Inspection, that where explosions are (or presumed to be) caused by low water the welded seams in or near the crown give out in a manner entirely suggestive of weakness; in other words, shortage of water and overheating of crown plates which in fire-boxes of the old construction meant the bulging and sagging of the roof, become disastrous explosions when there is a welded seam in the crown, which becomes overheated and consequently fails. The remedy clearly is to confine welding to patches and other repairs up to half-sides, or at any rate to have no welding in the crown sheet or its adjacent attached plates, as this has proved entirely unsafe.

Expansion Brackets.—Brackets corresponding to the simple and effective type generally used on British locomotives, Fig. 7 (opposite), are not customary in American practice; even with boilers having fire-boxes between the frames rather crude clips capable of sliding along the top rail of the bar frame are mostly used, Fig. 8; although a later type of bracket approximating to the British pattern is sometimes used on engines having fire-boxes of the same width as the outside of the framing and set over the top of the frame, Fig. 9.

The method generally adopted with the wide fire-boxes extending over the frames, as used in modern practice, is to support it by thin plates (about ½ in. thick) fixed to the front and back sections of the foundation ring, being connected to the engine framing by a cross-stay at the front end and by the back drag-casting at the rear. These plates are certainly a simple and inexpensive method of carrying the fire-box end, but the author prefers a definite sliding bearing to take the weight of the boiler, although such plates as mentioned are a good method of holding the boiler down in position, in addition to plain sliding bearings.

Circulating Tubes and Brick Arches.—A prominent feature of present-day American practice is the use of circulating, or arch tubes (generally three in number) in the fire-boxes. These tubes, which are usually 3 in. in diameter, extend from the lower part of the front water leg to the upper part of the back one, and serve the double purpose of promoting circulation and supporting the brick arch. They fulfil these duties effectually but need careful watching, and the inside of the tubes must be cleaned of scale, with a special tool, fairly frequently; undoubtedly the duty these tubes perform is an onerous one as the rate of ebullition in them must be very great, and this is evidenced by their often being unable to stand the extra duty entailed when oil fuel is used; in such cases it is found necessary to remove them.

Some twenty-five years ago similar circulating tubes were used to a large extent on American engines, but were afterwards discarded, apparently on account of maintenance troubles; certainly a number of accidents were caused by one end coming adrift under pressure, although the author has always believed this to be mostly due to the tubes of that time being carried from the front water leg to the crown plate (near the back end), thus forming a loop between two surfaces approximately at right angles, whereas the present ones always run practically straight between two opposing surfaces. There does not appear to be an absolute necessity for the tubes as arch supporters except for very wide fire-boxes, and on the remaining point as to whether the better circulation obtained is worth the increased maintenance, the author has not yet had sufficient experience with them to offer an opinion.

In connection with brick arches it is remarkable that for many years they were little used in American practice, and practically only came into favour again with the modern reintroduction of circulating tubes.

Fusible Plugs.—These are very often omitted in modern American practice; in fact, the author believes the majority of locomotives in Canada and the United States of America are without them. He has been informed that they have been done away with for the reasons that (1) they sometimes leak and cause delays when there has been no shortage of water; (2) when there has been a shortage of water they have been known to fail to act on account of (*a*) scale and hard deposit having accumulated on the water end so blocking the orifice, and (*b*) some change having taken place in the fusible metal, causing it to withstand a higher temperature than was intended; (3) it is considered that with the large boilers now in use the comparatively small hole would not have sufficient effect.

Regarding (1), from close investigation the author was led to believe that many cases of plugs leaking through the fusible section was due to the practice of using an inset consisting of practically a straight-tapped hole (with a large countersunk part at the top), and lining the inside of the plug before running in the fusible metal. The tin in the lining, melting out at a lower temperature than the actual fusible metal, thus defeated its object and left a leak round the fusible core. Cases have been known where plugs have been heavily tinned, and in a few days such tinning has disappeared and the inset had been loose enough to rattle, though still in position. With plugs cored out fairly large at the top, filled without any tinning, and the metal lightly tapped down from the top before cooling off, no trouble is experienced with false alarms. Regarding (2) (*a*) and (*b*): this is a question of periodical removal for inspection and renewal of the inset when needed. Regarding (3), this seems only a question of using a larger plug, or alternatively more than one plug in each area to be protected.

The author is entirely in favour of retaining fusible plugs, after some years' experience with them applied (at front and back) to long fire-boxes operating over suddenly alternating grades of 1 in 30; although not having much effect on large fires, or on the pressure in the boiler, yet they are sufficient to call the attention of the engineman.

Fire Holes.—The usual form of fire-hole flanging adopted in American practice is that in which the outer and inner plates are flanged towards each other and so have a riveted lap-joint midway between the shell and the inner box. This method, however, gives little opportunity for dealing with any leaks which may occur; if any rivets need to be removed it is impossible to replace them, and patch bolts must be used instead; further, the laps are apt to be cut away in caulking leaks, and cracks sometimes develop through the laps to the rivet holes. These are most difficult to deal with properly. Many of these difficulties disappear with the employment of electric welding, and in new boilers the plates are now generally welded together at the joint from the commencement, but nevertheless the experience of the author with various kinds of fire-hole arrangements used in connection with both copper and steel fire-boxes has been that there is nothing to equal the well-known "Webb" pattern.

Fire Doors and Deflectors.—The various effective forms of fire doors in use in British practice for many years, appear to have had no parallel in general American practice, as until the introduction of the automatic fire door the old swing type door held sway on most lines. The deflector, although introduced in America in the early "sixties" was seldom used, and is so even now, the reason generally given being that it interferes too much with the proper distribution of the fuel on the grate. This is so in many cases and the length and droop of the customary British deflector would be out of the question with most large fire-boxes, but it is possible to shorten and modify the deflector to whatever extent is necessary and yet retain some of its advantages. The automatic fire door, only remaining open while the fireman's foot is on the trigger, does not allow much cold air to enter, and makes more remote the probabilities of the deflector being much used in America.

Respecting mechanical stokers, they are absolutely necessary in many cases where the amount of fuel to be fed to the boiler precludes efficient hand firing. They do not appear likely to be needed in British practice for ordinary fuel, nor even for the largest boilers likely to be designed to suit the British loading gauges.

Fire Grates.—The entire difference in the practice of the two countries in respect to fire grates is, of course, on account of the different class of fuel used; the rocking grates and dumping sections (or drop-plates) used in America are essential for burning the class of bituminous coal used, which is often so small that it has to be heavily watered to prevent it being carried straight away off the fire by the blast. For the same reason the air spaces are less than in British practice, this fact explaining to a great extent why a greater steam-raising capacity can be got out of a given grate area in England than in America.

The dumping sections are required, as certain descriptions of coal used are liable to form clinkers, and these can be worked to the front (or back) end and pushed through the drop-plate during the course of a few minutes stop at a station. They are also of use when fires are drawn, as the fire is pushed through them into the ash pan with facility. The author would like to see drop-plates tried on some of the relatively long grates in British practice, to ascertain if their convenience is worth their upkeep in such cases. Trouble is likely to develop from warping, unless particular care is taken in designing the drop-plate casting, and the methods of locking the trunnions are important.

Ash Pans.—Owing to the greater variety of wheel arrangements used in America the ash pans are usually more complicated than the British, but conversely they are not so well constructed. A much thinner gauge material is generally used, and less trouble is taken to secure reasonable airtightness when dampers are closed; further, in most large modern locomotives the difficulty of providing sufficient air entrance area compels open spaces to be left all round the upper part of the ash pan near the foundation ring, and these spaces remain open permanently; also in many cases ash-pan doors have been superseded by netting, placed at an angle to prevent fire falling on the line, and provision for removing the ashes made by a sliding or other type of door in the floor of the ash pan. These arrangements are, of course, necessary, but the author considers it should not be beyond the scope of designers to arrange for doors to close all air entrances, as the amount of fuel wasted due to the enginemen not being able to close all air inlets when steam is not required is unjustifiable.

Damper gear is not usually very well finished, and often forked-end connections to the levers and rods are not provided where they might be; similarly, the accurate catches and close adjustments now common in British locomotives are not usually provided.

Flexible Fire-Box Stays.—In modern American practice a good many flexible staybolts are used, generally of the "Tate" or similar pattern, having the flexibility provided in the attachment to the outer shell. These stays are clearly very necessary in certain parts of the large fire-boxes used, as although there is not the difference in the expansion between the material of the inside and outside plates as when copper inside boxes are used as in British practice, yet the large area of plate exposed to the fire must produce very considerable relative displacement of the inside and outside plates and with a less ductile material.

Domes.—Domes are constructed in a similar manner in both countries, usually in one piece up to 2 ft. in height, and in modern practice they are pressed out of a single plate; above that size, three-piece construction is generally adopted.

The "Helmet" pattern with the joint low down, enabling the regulator and gear to be easily got at, is not often adopted in America; the domes used there, however, are much larger in diameter than in British practice and allow men to work at the regulator fairly easily without the low joint. The author considers the large diameter domes an advantage for obtaining dry steam and giving facility for entrance, &c.; in cases where the size of the boiler prescribes only a small diameter dome he considers the "Helmet" pattern preferable.

Lagging, Cleading, &c.—The American practice in lagging is similar to the British, but in respect to the cleading nothing like the same care is taken. No "Crinoline" bands are used, the cleading plates—always of much thinner gauge than used in British practice—being clamped directly on to the lagging, and neither the number or effectiveness of the securing clips and fastenings is comparable; the result being that the cleading does not, as is usual with British locomotives, last the life of the boiler, and the appearance is always inferior. These remarks also apply generally to the dome casings and other mouldings on the boiler, the sand-box thereon, &c.

Regulators.—For many years the standard British regulator valve has been of the sliding through-port type with auxiliary pilot valve, and regulator handle moving in a sector across the face of the fire-box back head, although certain railways used a type of pull-out handle. In American practice the circular double-beat partly-balanced regulator valve has all along been favoured, being always operated by a pull-out lever of special design incorporating a notched quadrant and catch with fine teeth. Present-day British practice also tends in the direction of the double-beat pattern, although generally with the old type handle, or variations thereon working across the fire-box.

It is unquestionable that with the circular type it is easier to maintain a good seat, and, if properly designed, any failure of the gear should cause it to close automatically. It is doubtful if there was any real advantage gained by the preliminary opening of the pilot valve in the sliding type, which could not have been obtained otherwise, all regulators are susceptible of gradual opening if proper leverage is provided.

Regarding the pull-out *versus* the cross-movement handle, the author is in favour of the former pattern with lever and catch; the driver has better control over it, not having to turn himself sideways. It can be brought to the most convenient position to his hand, and he is enabled to look ahead, having one hand on the regulator handle, the other on the brake handle and operate them both without taking his eyes off the line ahead of him.

Internal Main Steam Pipes.—These are usually of copper with brass sleeves brazed on at the ends for jointing purposes, in British locomotives; the American practice being to use steel tubing with cast-iron or cast-steel end sleeves attached to the pipe by a number of small rivets. The steel pipes are liable eventually to suffer from corrosion, particularly near the sleeve at the front tube-plate end; the author favours the use of copper for such pipes for this reason, also because of its better fastening to the end pieces, although a good steel pipe with bronze end pieces properly attached should, and does, make a good job.

(To be continued.)

BLAST FURNACES IN HOLLAND.—It is reported that two American blast furnaces are being built at Ijmuiden, near Haarlem, Holland, one of 250 tons and one of 300 tons daily capacity.

THE OPPOSED PISTON OIL ENGINE.—Messrs. William Doxford and Sons, Limited, Sunderland, have agreed with the Sun Shipbuilding Company, Chester, Pennsylvania, U.S.A., to unite the interests of the American Junker patents with the Doxford patents which have been the basis of the developments forming the Doxford opposed-piston oil engine. The Sun Company have secured the full license for America and its possessions of the Junker patents, and will operate both interests in America. An immediate start is to be made at the Chester Works on the construction of four-cylinder, 3,000 h.p. single-screw installations, being repeats of Doxford's manufacture, two of which are already at sea in the motor-ships Yngaren and Dominion Miller; further repeats are in hand at Sunderland, and arrangements are in progress for similar engines at the Belfast Works of Messrs. Workman, Clarke and Co., and also on the Clyde at the works of the Fairfield Shipbuilding and Engineering Company.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

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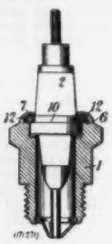
GAS ENGINES, PRODUCERS, HOLDERS, &c.

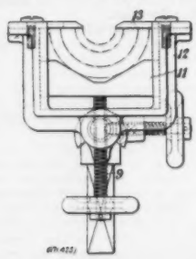
171,271. The Sphinx Manufacturing Company, Limited, Birmingham, and W. A. Clarke, Birmingham. Sparking Plugs. (1 *Fig.*) September 25, 1920.—In a sparking plug, according to this invention, a flange or web 7 integral with the shell or body part 1 of the sparking plug is turned down on to a



copper, or asbestos or like compressible washer 12 seated or directly bearing partly upon an annular shoulder 6 on the body part, and partly upon a corresponding annular shoulder 10 of or on the insulator 2 to bridge or cover the space, joint or recess around these members. (*Accepted November* 23, 1920.)

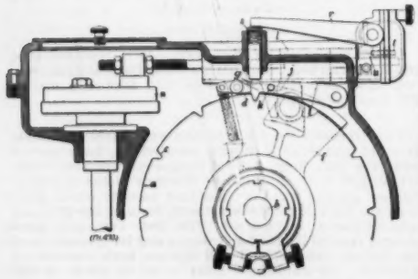
MACHINE AND OTHER TOOLS, SHAFTING, &c.

171,425. W. C. C. Sykes, London. Vices. (3 *Figs.*) February 28, 1921.—According to this invention, a clamp for a bearing brass comprises a yoke 12 having abutments 13, preferably adjustable, adapted to engage with the flat diametrical



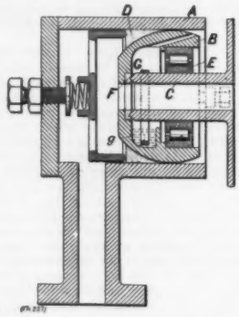
surfaces of the semi-cylindrical brass and has a slidable V-shaped wedge block 11 to engage with the curved outer surface of the brass, the block 11 being displaceable within the yoke to clamp the brass against the abutments 13, and operating by means of a threaded spindle 9. (*Sealed.*)

171,473. H. F. L. Orcutt, Handsworth, Birmingham, and The Gear Grinding Company, Limited, Handsworth, Birmingham. Grinding Machines. (1 *Fig.*) May 13, 1921.—The inventions relates to machines for grinding gear wheel teeth or shaft splines. The invention provides an improved dividing head whereby the necessary high order of accuracy in the intermittent angular movements of the work can be obtained conveniently. A disc *a* is secured to the spindle *b*



and is formed with peripheral notches *e* at intervals corresponding to the number of wheel teeth or shaft splines on the work-piece to be ground. Each notch *e* is engaged in turn by a spring pawl *d* carried on an arm *f*, mounted coaxially with and alongside of the disc *a*. Adjacent is a spring-locking pawl *g* which fits the notches *e* and engages each in turn for the purpose of rigidly locking the disc. To lift the pawl *g* out of action, the outer end of the arm *f* is shaped as a cam *j* and engages a projection *k* on the pawl. Motion is given to the arm *f* by a slide *l* actuated from a crank *n*, the latter receiving its motion at proper intervals from some part of the grinding machine. Adjacent to the slide is a bell crank lever *r*. One end of this lever acts on a cup *s* containing a spring. The other end of the lever is fitted with an adjustable screw stop *t* which can coact with an abutment *u* on the slide. During a small portion of the movement of the slide when it is completing its traverse from left to right, the abutment strikes against the stop and causes the lever to press on the cup *s*, the pressure being transmitted through the spring to the pawl *g* and serving to force the tapered end of the pawl firmly into the adjacent notch in the disc. This insures accurate positioning of the disc. Preferably the movement given to the disc by the pawl *d* is slightly short of that required to bring the disc at each operation into the proper position, the final positioning being effected by the action of the lever *r* on the pawl *g*. During the movement of the slide from right to left, the lever *r* is free so that it offers no interference to the raising of the pawl *g* out of engagement with the disc by the arm *f*. (*Sealed.*)

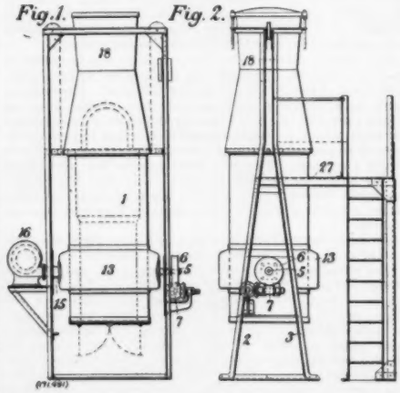
171,237. W. Mycock, Whitworth. Bearings. (2 *Figs.*) September 9, 1920.—The invention relates to the bearings or "doll-heads" of the cylinders of drying machines. The doll-head casing A has a bush B of spherical external contour fitted therein to receive the trunnion C of the cylinder and is held in position by a packing D. The bush B is recessed in its interior



and is fitted with a roller bearing E within which the trunnion C is journalled. The end of the recess is bored out, and into it is fitted an anti-friction washer F. The end of the trunnion is preferably bevelled as shown. The interior of the bush B may be formed with an oil well *g*, and a ring oiler G may be placed on the trunnion depending into the oil well to maintain the end of the trunnion constantly lubricated. (*Sealed.*)

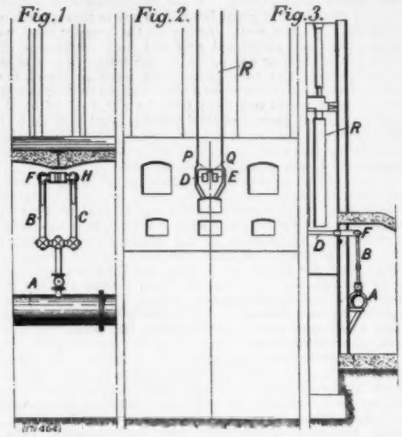
MINING, METALLURGY AND METAL-WORKING.

171,491. W. H. Wood, Moseley, Birmingham, and D. H. Wood, Moseley, Birmingham. Cupolas. (3 *Figs.*) August 19, 1920.—The invention relates to cupolas of the type having an air belt which carries hollow trunnions through which the air blast is introduced, the trunnions also allowing the furnace to be tilted for repair. The invention particularly relates to cupolas known as cupolettes. According to the present improvements, the cupola 1 is pivotally mounted in a frame work 2, 3, and a spark arrester 18 is slidably mounted in the framework so as to be disengaged when the cupola is to be tilted and to be engaged therewith when the cupola is in the upright position. By the present invention also the several components of the



cupolette are arranged together in a compact form whereby the cupolette forms a self-contained structure; and in this connection the structure comprises in combination a cupola 1 having an air belt 13 thereon, trunnions 5 carried by the air belt for pivotally supporting the cupola in the framework 2, 3, a pipe 15 forming a bearing for a hollow trunnion and being connected direct to a fan or blower 16 mounted on the framework 2, 3, a worm wheel 6 mounted on the other trunnion and engaging a worm 7 for tilting the cupola, a spark arrester 18 mounted on the framework and a platform 27 connected to the framework. (*Sealed.*)

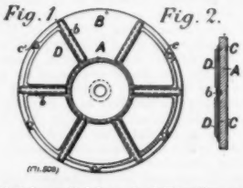
171,464. Coke and Gas Ovens, Limited, London, and A. R. Smee, London. Coke Ovens. (3 *Figs.*) August 12, 1920.—The invention consists broadly of a coke oven burner arrangement comprising in connection with one set of heating flues two gas supply sets adapted to be used alternately, one for supplying the necessary volume of gas for combustion while the other conducts a quantity of air sufficient to burn away the graphite previously deposited, and *vice versa*. Two separate supply pipes B, C are adapted to conduct gas from a gas main A to two separate horizontal channels D, E, each to each, the channels D, E being in turn adapted, through the medium of short branch pipes P, Q, to supply the gas for combustion to burner nozzles in the vertical heating flues R in the oven wall. The passage of the gas from the pipes B, C to the corresponding horizontal channels D, E is controlled by means of two three-way cocks F, H, each of which is adapted in one position to afford free passage of the gas from the supply pipe to the horizontal channel and in another position to cut off the former from the latter and provide communication between the latter and the atmosphere.



In operation, the cocks F, H are usually manipulated so that one of the horizontal channels is supplied with gas whilst the other is supplied with air, the air burning off the graphite deposit in the one set of nozzles whilst the gas is being supplied to the other, and no loss of heat occurring in the oven walls in the process of burning off the graphite. (*Sealed.*)

MOTOR ROAD VEHICLES.

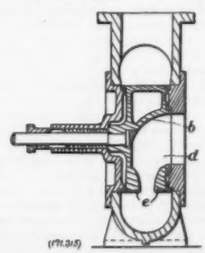
171,503. O. D. Cars, Limited, Belfast, and J. H. Longden, Belfast. Friction Clutches. (5 *Figs.*) August 25, 1920.—The invention relates to flat disc friction clutches of the type in which the driven member is gripped between a pair of driving members, the faces of which are covered with friction fabric. This invention consists in constructing the flat disc driving members A of the clutch with a number of segmental



spaces B divided by radial keys *b* of T-section, and removable segmental friction plates or carriers B of steel or other material, each with a friction surface D affixed thereto, each plate being held in position by the radial keys *b* and by a set screw *c*¹ passing through a lug *c* in the plate and readily detached and replaced when the friction material is worn or requires renewal. In some cases the driven member may be constructed in a similar manner. (*Sealed.*)

PUMPS.

171,315. J. S. Hazell, Forest Gate, London, and Unchokeable Pump, Limited, London. Centrifugal Pumps. (2 *Figs.*) December 9, 1920.—The invention relates to centrifugal pumps in which the impeller is provided with a single port or opening for the passage of the liquid. According to the invention, in order to avoid slip, the passage *d* in the impeller *b* at the discharge



end thereof is provided with one or more radially-disposed vanes or projections *e*, or, instead of projections, the surface of the passage at this point is corrugated or otherwise shaped or treated to increase the grip upon the liquid. Instead of, as heretofore, rounding only one of the walls at the discharge end of the passage in the impeller both are so shaped. (*Accepted November* 23, 1920.)

THE "PRACTICAL ENGINEER" POCKET BOOKS, 1922.—We have received from the Technical Publishing Company Limited, of 1, Gough-square, Fleet-street, E.C. 4, copies of both the "Practical Engineer" Mechanical Pocket Book and Diary, and the corresponding "Electrical Pocket Book" for the current year. Both these little handbooks are too well known to need description, the former being in its thirty-fourth and the latter in its twenty-third year of issue. They contain all the tabulated matter likely to be required for reference in ordinary work, as well as short sections of concise descriptive matter. Each book is published at 2*s.* or 2*s.* 6*d.* net, according to the binding.